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Beekeeping

in Western Canada





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Beekeeping

in Western Canada



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Foreword

Canada is a leading honey producing country, ranking behind China, the United States, Mexico and Argentina. Canada produces an average of 31.5 thousand tonnes of honey annually (Statistics Canada, 1990-95), with the three prairie provinces accounting for 76.5 per cent or 24.1 thousand tonnes. Alberta produces the most honey, averaging 10 thousand tonnes annually, or 30 percent of Canada's honey production. Saskatchewan has the highest per colony yield at 86 kg per year per hive. Honey produced in the prairie provinces has a light color and a mild flavor and is highly regarded on the domestic and international markets for table use and for blending with darker honeys produced elsewhere.

Beekeeping conditions on the Canadian prairies are unique. Hot summers, large areas of cultivated nectar-producing crops and a short but intense nectar flow result in yields averaging up to 90 kg (200 lb) per hive. On the other hand, long severe winters present unique problems in the overwintering of bees.

There is a wealth of literature concerned with the biology and management of the honey bee. However, most of this material has been directed to beekeeping conditions in the United States and Europe. This book has been prepared to assist beekeepers in the management of honey bees under prairie conditions. It should be seen as a supplement to the references listed in Appendix B and other extension literature.

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The Honey Bee

The Importance of Pollination

Bees are thought to be the most efficient of the insect pollinators. The honey bee remains one of the few pollinating insects that can be cultured, managed and moved in great numbers to a crop requiring pollination. Thus, the value of the honey bee to our economy is far greater than merely that of the honey and beeswax produced. For agricultural crops, honey bee pollination contributes anywhere from ten to one hundred times the monetary value of honey and beeswax, and this figure does not include the aesthetic value of cultivated and wild ornamentals or their value to wildlife.

Many plant products that we consume depend on or benefit from pollination. As well, many insect-pollinated plants form part or all of the diet of many animals raised for milk and meat production. Insect-pollinated legumes have the added role of soil enrichment through their nitrogen-fixing capacity.

Inadequate pollination leads to reduced crop yields, delayed or uneven fruit and seed set and lower fruit quality. Insect-pollinated ornamentals, both cultivated and uncultivated, brighten the landscape, provide shelter and food for wildlife, and aid in soil stabilization.

In many areas of the world, the populations of native bees have suffered as a result of changing agricultural practices, the use of pesticides and widespread land clearing and consequent elimination of nesting sites.

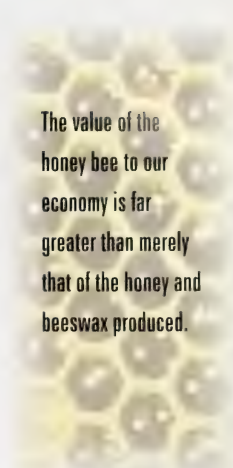
Honey Bee Classification

Honey bees are members of the class Insecta, which includes all insects such as dragonflies, leafhoppers, butterflies, beetles, mosquitoes and wasps. Insects are, in turn, part of a larger group, the Arthropoda (jointed legs), which includes four other classes:

- Arachnida (spiders, ticks, scorpions, and mites),
- Chilopoda (centipedes),
- Diplopoda (millipedes), and
- Crustacea (lobsters, shrimp, barnacles, and crayfish).

Members of the class Insecta are characterized by having a protective exoskeleton or outer shell, three pairs of legs, one pair of antennae, a segmented body divided into head, thorax and abdomen and, often, one or two pairs of wings.

Within the Insecta, there are smaller groupings or orders, and honey bees are in the order Hymenoptera ("membrane-wing"). This order also includes sawflies, wasps, ants and other solitary and social bees. There are about 20,000 species of bees in the world, about 3,300 of these are native to North America. Most species of bees are solitary, but some live communally and some, such as the bumble and honey bees, have developed a truly social life style.



The value of the honey bee to our economy is far greater than merely that of the honey and beeswax produced.

Bees can be distinguished from the other members of the Hymenoptera because they have long, well-shaped tongues and numerous branched (plumose) body hairs. Male bees can be distinguished from females because the males have 13 antennal segments and 7 visible abdominal segments, whereas the females have only 12 antennal segments, 6 visible abdominal segments and a sting! In most species, females also have a pollen-collecting apparatus located on the underside of the abdomen or on the hind legs.

Bumble bees and honey bees are in the family Apidae; the scientific name of the western honey bee is *Apis mellifera* (L.), meaning “honey-bearing bee.” Thus beekeeping has been named “apiculture,” or the culture of *Apis*.

Several other species of *Apis* species are recognized at present. *Apis florea*, the little honey bee, *Apis dorsata*, the giant honey bee or rock bee, *Apis laboriosa*, and *Apis andreniformis* all build single comb dwellings in sheltered but open areas. The comb size of these species varies from 20 cm to almost 2 metres in depth.

Other species of honey bees such as *Apis cerana indica*, the Indian honey bee, *Apis koschevnikovi*, *Apis nigrocincta*, *Apis nuluensis* and *Apis mellifera* live in closed cavities. *Apis cerana* can also be managed for honey production and crop pollination because it builds multiple comb dwellings and is similar in many respects to *Apis mellifera*, though its colonies are smaller in size.

Apis mellifera has been further categorized into a number of different races. Several geographic races of *Apis mellifera* in Europe have developed in isolation from one another and have evolved characteristics that suit them to their particular environments. None of these races is native to the Americas, but all have been introduced at one time or another.

The Italian bee, *Apis mellifera ligustica*, is known for its golden color, its gentleness and its tendency towards prolific brood rearing and populous colonies throughout the season. Because of this tendency, its food consumption is high throughout the year, including the winter. The Caucasian bee, *Apis mellifera caucasica*, is a darker-colored bee, quite gentle, with a somewhat slower buildup in numbers, strong colonies and a strong tendency to propolize. The Carniolan bee, *Apis mellifera carnica*, is also dark-colored, quiet and gentle, with its brood production closely related to the availability of pollen; it characteristically overwinters in small colonies and with less food consumption. The dark bee, *Apis mellifera mellifera*, is very dark in color, with a tendency to be nervous and aggressive; it has a slow spring buildup.

Other races of *Apis mellifera* include those that originate in Africa, the most famous (or infamous) of which is the African bee, *Apis mellifera scutellata*. Traits of this race are extreme aggression, small colonies, lack of clustering ability (since this race does not need to winter) and a tendency towards both migratory and reproductive swarming behaviour.

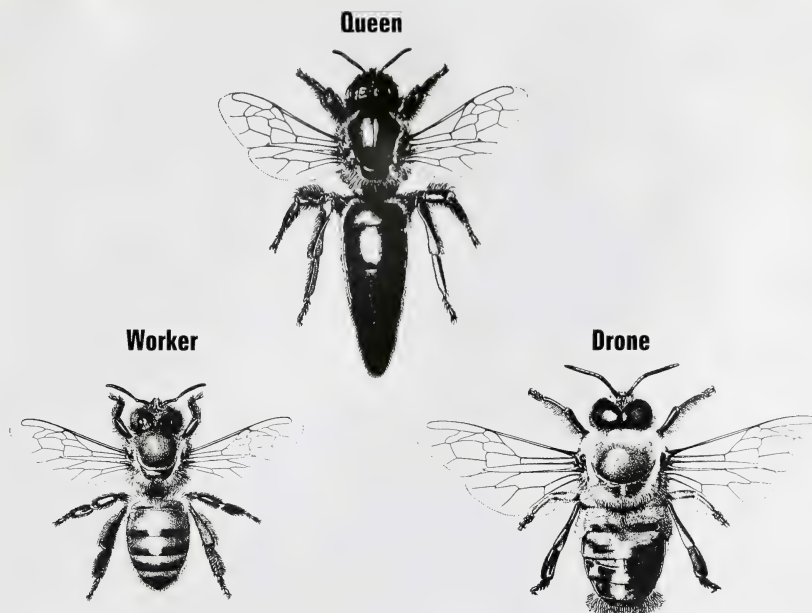


Figure 1. The three castes of the honey bee: Queen, Worker, Drone. (Taken from Dade, 1977).

Biology of the Honey Bee

Before taking up beekeeping as either a hobby or a full-time occupation, you need some knowledge of honey bee biology. Through knowledge of the natural instincts of the honey bee colony and adaptation of management techniques to specific situations, you will attain maximum honey production.

The colony

The honey bee colony is a family consisting of a single mother, the queen; thousands of daughters, the workers; and a varying number of sons, the drones. The three castes – queen, worker and drone – differ in size and shape (Figures 1 and 2) and are each specialized to perform certain tasks within the colony.

This specialization and consequent interdependence of the castes makes the honey bee colony a truly social unit. Consider the colony to be like an individual “organism” consisting of anywhere from 10,000 to 60,000 “cells,” none of which can exist for very long away from the “others.” The “organism” perpetuates itself through successive cycles of brood rearing. Reproduction of the “organism” – the colony – occurs through swarming.

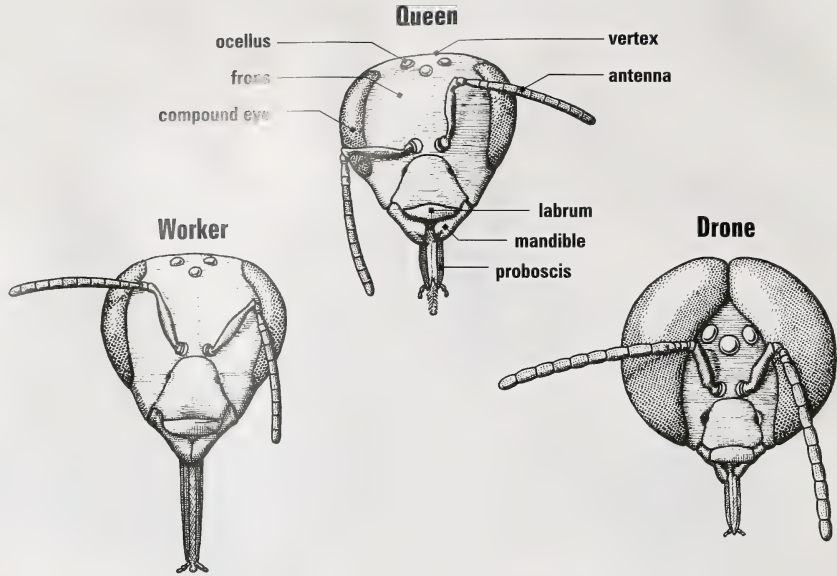


Figure 2. Heads of three castes of honey bee: Queen, Worker, Drone. (Modified from Dade, 1977).

The nest

The physical dwelling place of the bee is the nest or hive, while the bees themselves form the colony. The colony nests in a dark enclosed cavity, such as a hollow tree or within the wall of a building, which provides protection from predators and inclement weather and allows regulation of the temperature and humidity.

Wax combs built by the young worker bees form the substrate, or material, of the nest. Perpendicular combs are attached to the top of the cavity and are built more or less parallel. The distance between combs is about 8 mm, which is sufficient to allow the passage of the queen, workers and drones and is thus referred to as the “bee space.”

Combs are made up of six-sided (hexagonal) cells extending out and angled slightly upwards from both sides of the mid-rib. The cells are used for brood rearing and food storage. Brood is reared in the centre of the nest in a hemisphere or sphere; pollen is stored above and to the sides of the brood, and honey is stored above and to the sides of the brood.

Most of the combs are made up of worker-sized cells, but some drone comb will be built along the bottoms and sides of combs (Figure 3). Queens are raised in specialized queen cells, which begin as queen cups and when drawn out and capped, hang in a vertical position on the comb (Figure 4).

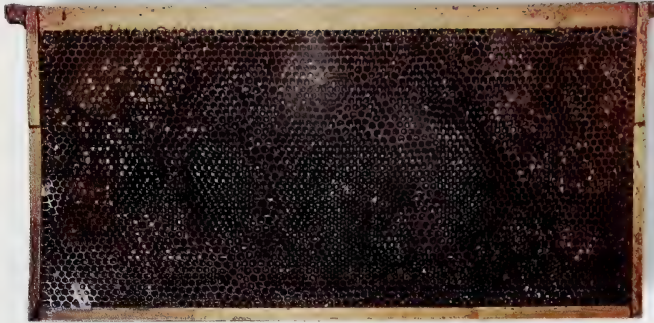


Figure 3.
Drone-sized cells
along bottom and
end bars.

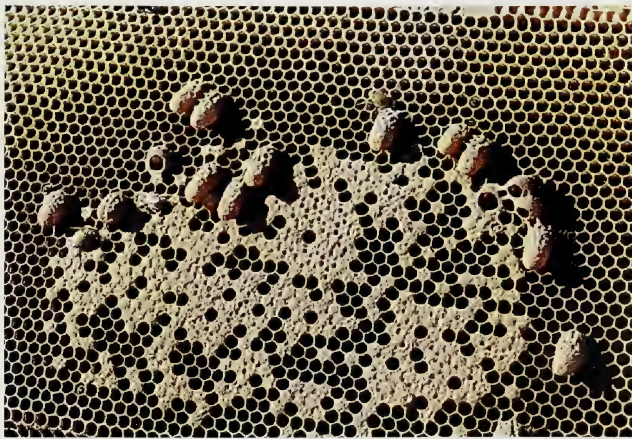


Figure 4.
Queen cells shown on the
face of a comb.
(Photo D. Nelson)

Seasonal cycle

The races of bees used in Canadian beekeeping are adapted to a temperate climate, and the cycle of colony development follows the cycle of the seasons. While other species of social bees, such as bumble bees, survive the winter by having only the new queens hibernate, honey bees maintain perennial colonies with both queens and workers surviving from fall through to spring.

European honey bees store food, when available, far in excess of day-to-day demands in order to survive periods of dearth and inclement weather. When too hot, they can control the temperature of the brood nest by air circulation and evaporation of water. When they are too cold, they cluster together and generate heat energy. This adaptability allows colonies to survive in nearly every environment inhabited by the human race.

In spring, an overwintered colony of bees may consist of from 10,000 to 20,000 individuals or more. With the onset of the spring pollen and nectar availability, the colony begins to increase in numbers, providing there is access to food and water. A shortage of honey, pollen or water will lead to a temporary reduction or cessation of brood rearing.

As the number of worker bees increases and more are available to maintain the brood nest, the size of the brood nest increases, and the colony expands in an upward direction, taking

advantage of the heat rising from the brood nest. Headed by a queen with optimum laying capacity and no limits on food and space, colony populations can increase to a maximum of approximately 60,000, comprised of a single queen, a few thousand drones and many workers.

If conditions warrant, in the late spring and early summer, the colony may begin swarming preparations. Swarming is initiated when the amount of queen substance available to the worker population becomes too low to maintain colony cohesion. This situation may occur when rapidly expanding colonies become crowded, limiting the dispersal of queen pheromone which, in turn, results in queen cell construction. In addition to pheromone control, however, other factors such as the level of queen pheromone production, brood cell space, ventilation and the availability of space for egg-laying and food storage also play important regulatory roles in swarming.

Prior to swarming, when space available for egg laying is reduced, the queen is said to become “honey bound.” At this point, new queens are produced in queen cells while the old queen’s egg-laying rate falls off, and her abdomen reduces in size. Her nurse bees tend to feed her less, agitate her and eventually force her out of the hive with a good portion of the workers and drones.


The swarm generally issues around midday when it is sunny and warm, often on a day following a period of inclement weather, during which the whole population has been crowded into the hive. The swarm generally settles on a branch, a fence post or in some such location close to the hive and remains there while scout bees search for a new home, returning to communicate their findings by means of the same sort of bee dance used to recruit foragers. Eventually, one of these locations receives the majority of visits and recruitment of most of the foragers sent to investigate its suitability, and the swarms move to this location to start a new home.

In the meantime, a virgin queen will emerge from one of the queen cells in the “parent colony.” She also may leave the parent colony with a smaller number of workers, termed an after-swarm. Several such after-swarms may issue, or one of the virgin queens may search out and sting the other queens in their cells. Once mated, the new queen will then become the mother of the parent colony.

Throughout the spring, the colony continues to build toward a peak population, and excess honey and pollen are stored through the main summer nectar flow. Once the flow ceases and the summer draws to an end, the colony population decreases through a slowdown in egg-laying and brood rearing, the eventual death of worker bees and the expulsion of the surplus drones from the colony. Worker bees that hatch in late summer will live for several months and will form the wintering population.

As fall progresses, egg-laying by the queen generally ceases, and there is a period of from one to three months during winter when there is little or no brood rearing. As temperatures cool, the bees gather together, and at about 14°C, they form a well-defined cluster which then contracts further as ambient temperatures grow colder. Although very little activity occurs in the winter cluster, the bees do not hibernate. Instead, they eat honey and generate heat through rapid thoracic-muscle vibrations. Through the winter, the cluster gradually shifts position in the hive to utilize all the honey stores. Temperatures are maintained at 6-7°C at the edge of the cluster and at 29°C in the centre.

Although very little activity occurs in the winter cluster, the bees do not hibernate.



Some time in January or February, the colony resumes brood rearing, and the temperature within the cluster is maintained at about 33°C. Brood rearing causes the workers to age rapidly because of the stresses related to royal jelly production. Honey consumption within the hive increases from a maintenance level of 1.5-2 kg/month to 7-8 kg/month. By early spring, colonies may be getting short of pollen and honey, depending on the severity of the winter and the rate of brood rearing. The onset of spring temperatures, nectar and pollen flows allow the renewal of food stores and the rapid expansion of the brood nest, and the cycle begins again.

Growth and development

Each caste passes through the same developmental stages from egg to adult, although their total developmental time is different (Table 1 and Figure 5). Queens take about 16 days to develop from egg to adult, workers about 21 days and drones about 24 days.

The life cycle of a typical worker bee can be used to explain the development. Once the egg has been laid in a cell, the embryo within the egg develops for three days and then hatches into the first larval stage (instar), which at this time is about 1.6 mm in length and is coiled in the end of the cell.

Provisioned first with royal jelly produced by the young adult workers, and later with a mixture of modified jelly, honey and pollen (bee bread), the worker larva feeds and grows over a period of five days. During this period, it moults four times, shedding its skin and increasing in size. By the eighth day, it has increased its weight by 1,500 times and fills the end of the cell. House bees cap over the cell on the eighth day, and over the next three days, the larva stretches out lengthwise in the cell and spins a silken cocoon in which to pupate. The larva then moults for the last time.

The stages between the grub-like larva and the adult bee are referred to as the pre-pupal and pupal stages. At about the twenty-first day, the new adult worker is fully developed and begins to chew at the cappings imprisoning her in her cell. She finally emerges as a “baby bee,” which is easy to recognize by her uncertain steps, light color and fuzzy appearance.

Table 1. Length of development stages of the honey bee

Day	Workers		Queens		Drones	
	Stages	Moult	Stages	Moult	Stages	Moult
1	Egg	(hatching)	Egg	(hatching)	Egg	(hatching)
2		1st moult		1st moult		1st moult
3		2nd moult		2nd moult		2nd moult
4		3rd moult		3rd moult		3rd moult
5	1st larval	4th moult	1st larval	4th moult	1st larval	4th moult
6	2nd larval	(sealing)	2nd larval	(sealing)	2nd larval	(sealing)
7	3rd larval	5th moult	3rd larval	5th moult	3rd larval	5th moult
8	4th larval		4th larval		4th larval	
9	Gorging		Gorging		Gorging	
10	Pre-pupa		Pre-pupa		Pre-pupa	
11	Pupa	6th moult (emerging)	Pupa	6th moult (emerging)	Pupa	6th moult (emerging)
12						
13						
14						
15						
16						
17						
18						
19						
20						
21	Adult					
22					Adult	

modified from Bertholf, L. M. 1925. The moults of the honey bee. *Journal of Economic Entomology* 18(2):380-384, taken from (Laidlaw 1979).

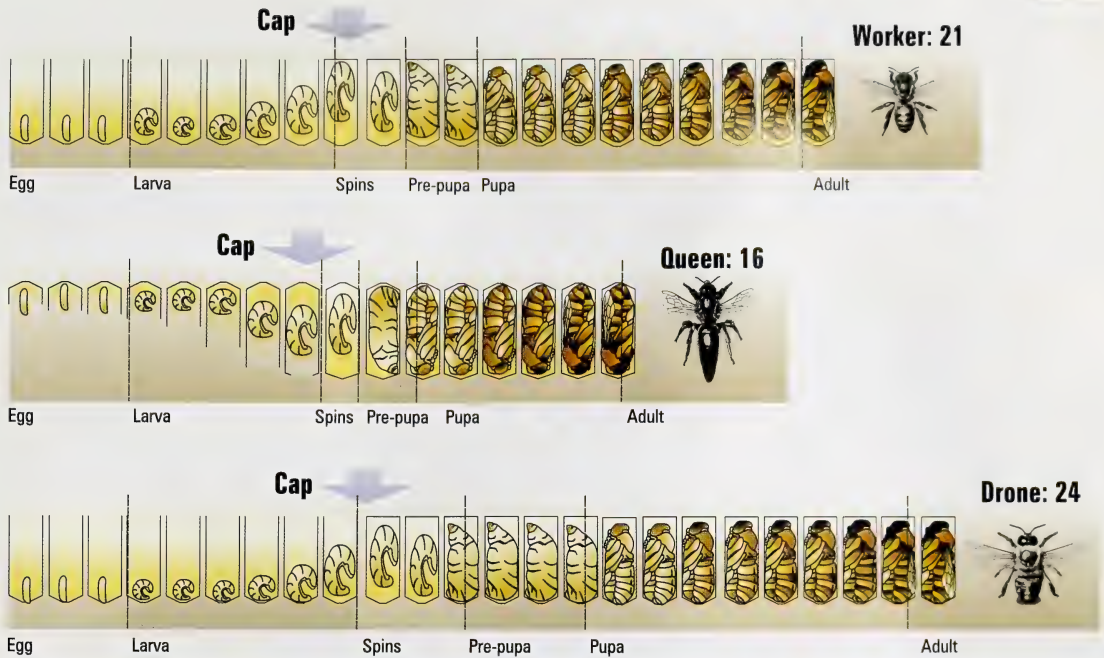


Figure 5. Length of developmental stages of the honey bee. Each cell depicts a duration of one day in the indicated life stage. (Modified from Winston, M. L. 1987. *The Biology of the Honey Bee*. Harvard University Press. Cambridge, Massachusetts).

The mated queen

The mated queen is the central figure of the colony. It is she who lays the eggs that develop into workers, drones and queens. She also maintains colony cohesion through production of chemicals called pheromones.

The queen's retinue pheromone (queen substance) is produced by her mandibular glands and consists of a complex blend consisting of 9-oxodecenoic acid, 10-hydroxydecenoic acid, methyl p-hydroxybenzoate and 4-hydroxy-3-methoxyphenylethanol. These pheromones are first picked up by the nurse bees who touch the queen with their antennae and then lick the queen. Pheromones are then passed through the process of worker-worker contacts and food exchange (trophallaxis) to every colony member.

The queen's mandibular gland pheromones act to influence several inclinations:

- to swarm or supersede,
- to attract drones during mating,
- to stimulate foraging,
- to enhance swarm clustering, as well as to suppress worker ovary development (see Chapter 11 for a more detailed explanation of queen biology and her role in the colony).

The queen has no part in caring for the brood, and it is the worker caste that feeds and cares for the brood and performs all the household and field tasks.

Drones

Drones are produced primarily in the late spring and early summer. They perform no specialized tasks within the hive, serving only to mate with virgin queens. Mature drones, a week or more in age, leave their hives on warm sunny days and can fly several kilometres from the colony in search of queens. Mating occurs in mid-afternoon while both drones and virgin queens are in flight.

The virgin queen is very effective at attracting drones through a combination of olfactory (pheromones) and visual cues. Stimulated by the queen's pheromones, her potential mates vigorously pursue her in a group that are collectively referred to as a "drone comet." Ten to fifteen drones may eventually succeed in mating with each queen on one or more of her mating flights.

Although each queen typically mates several times, individual drones mate only once and then die immediately afterwards. The exact location of mating is unknown, but there is some evidence to suggest that drones may fly regularly to specific mating sites called congregation areas. Drones that are unsuccessful in mating and that survive until fall are usually forced from the hive by the worker bees and then die.

Workers

Worker bees have many tasks to perform during their adult lives. The worker's life is divided into two main periods: the hive period (house bees) and the field period (field bees). Each period lasts about three weeks through the summer months.

Workers perform a general sequence of tasks according to age and the stage of physiological development, with much overlapping of tasks, omissions of tasks and "preferences" for certain tasks shown by individuals. Each bee performs many different duties through the day, interspersed with frequent rest spells. Housekeeping duties of the worker bees include the following:

- feeding the larvae,
- building new wax combs,
- capping brood and honey cells,
- processing nectar and pollen for storage,
- feeding the queen and drones,
- removing dead brood, adults and foreign material from the hive, and
- ventilating and defending the colony.

Newly-emerged workers engage in cell-cleaning activities and begin feeding older larvae with pollen and nectar. From about the sixth to the twelfth day of worker bee development, the hypopharyngeal glands in their heads produce royal jelly, a protein-rich food that they feed to larval workers, drones and queens. The queen's retinue is also made up of these young workers, who continually care for her and feed her with royal jelly.

When about a week old, worker bees begin short orientation or "play" flights. These flights often occur in the early afternoon of warm sunny days. Many young bees fill the air in front of the hive and hover there facing it, apparently memorizing the orientation of the hive and any landmarks that will aid in locating their home. After a short time, the bees re-enter the hive and the excess activity ceases.

Comb building is undertaken by workers once their wax glands have begun functioning, between day 12 and 18. The 4 pairs of wax glands are located under the plates or sternites of abdominal segments 4 through 7 of the worker (Figure 6), and they secrete scales of wax 1 to 2 mm diameter into the pockets beneath the sternites. The workers engaged in comb building hang quietly in festoons, manipulating the wax scales from abdominal pockets to mandibles, chewing and softening the wax and depositing it on a comb, where it is worked and smoothed over. Neither the queen nor the drones develop wax or hypopharyngeal glands.

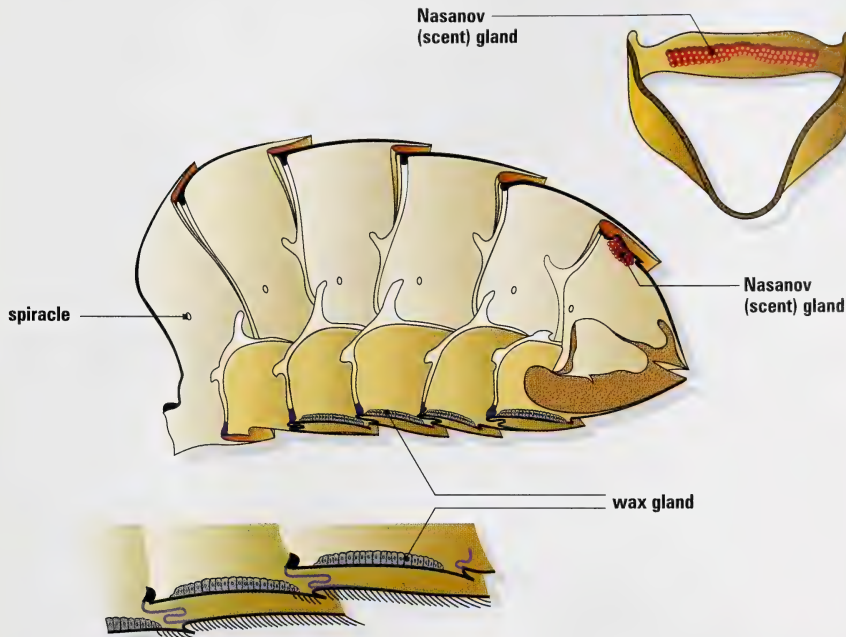


Figure 6. The wax and Nasanov (scent) glands of the worker honey bee. (Modified from Snodgrass in *The Hive and the Honey Bee*, 1975).

Older house bees may take on colony defense and temperature regulation duties when they are physiologically no longer able to feed young larvae or produce wax. Guard bees stand at the entrance to the hive and intercept strangers and insects of other types should they try to enter the hive. In times of honey flow, any forager loaded with honey or pollen will be allowed in. When the colony has been disturbed by predators or during dearth periods when strangers are likely to be robber bees, the guard bees are greater in number and alert to any disturbance, which they will investigate at once.

Fanning behavior may be noted at hive entrances during hot summer days. Fanning sets up a current of air through the hive, cooling the interior and driving off excess humidity from ripening honey. Fanning will also occur when bees are shaken from frames in front of a colony, or when a swarm of bees is entering a brood box. In such situations, the workers bend the tips of their abdomens down to expose the Nasanov or scent gland, located between the sixth and seventh segments (Figures 6 and 7). The volatile secretion from this

gland is carried on the air current set up by wing fanning and serves to orient and attract other bees towards its source. Exposure of the Nasanov gland may also occur at food and water sources to mark their location for inexperienced foragers.



Figure 7.
Worker bee fanning while
exposing Nasanov (scent)
gland.
(Photo J. Gruszka)

Honey bees have two pairs of wings, which are normally folded along the back at rest. The rear wing has a row of hooks (hamuli) on its leading edge (Figure 8) that fasten to a fold in the trailing edge of the fore wing, serving to hold each set of wings together for fanning or flight.

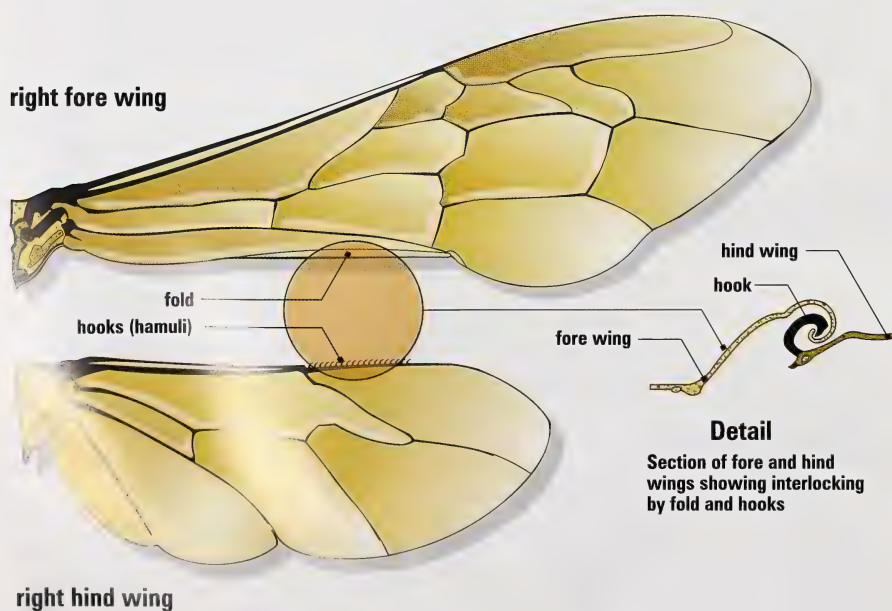


Figure 8.
The wings of the worker honey bee. (Modified from Snodgrass in
The Hive and the Honey Bee, 1977).

Foraging duties begin at about three weeks of age and continue for the remainder of the worker's adult life. During this time, pollen, nectar, water and propolis are gathered in the field and brought back to the hive, where they are transferred to house bees that take over the processing and storing tasks. At the height of the summer season, field workers forage for about three weeks before becoming worn out and dying.

Although there is a sequence to the ages at which workers normally perform tasks, bees of any age can perform any of the tasks required to ensure normal colony functioning. In a colony made up solely of young workers, for example, some will never feed brood or clean house but will go directly to foraging, while others will continue to perform house duties. Depending on the needs of the colony and the stimuli received by the workers, there is some flexibility in the system.

Colony Food Requirements, Collection and Processing

The bee-plant relationship

Bee species and the flowering plants are thought to have evolved together, with the inter-relationship centred around the production and collection of pollen and nectar as a food source. Without flowering plants, bees could not live; without bees, many species of flowering plants would not exist.

The hairs on the body of the bee are feathered to facilitate capture of pollen grains, and pollination of a flower often occurs as a by-product of a bee's search for nectar and pollen. Nectar can be looked on as a "bribe" or "reward" offered by the flower to the bee in exchange for pollination.

Other plant characteristics that help attract pollinating bees include bright-colored, showy and aromatic flowers. Color may act as a long-distance attractant while aroma may stimulate landing and the search for nectar and pollen. It is interesting to note how closely these features are related, for when a flower has been pollinated and fertilized, nectar secretion and aroma production cease almost at once.

Nectar is secreted by glands called nectaries (Figure 9), which are generally located within the flower but that may be extrafloral in some plant species. Pollen is the male sex cell of the plant and is produced within special organs called anthers, which along with their supporting filaments make up the stamens. The female sex cells, the eggs, are located within the ovary at the base of the pistil.

Generally the stamens, pistil and nectaries (Figure 9) of bee-pollinated plant species are located in such a manner that when the bee probes the flower for nectar, she must brush by the anthers and the receptive area of the pistil. Pollen grains from a previous flower of the same species, caught in the feathered hairs of the bee, adhere to the receptive, often sticky, stigmatic surface as the bee pushes past.

The pollen grains germinate on the stigmatic surface and send pollen tubes to the ovary, through which the male nuclei travel. Fertilization of a flower occurs when the nuclei of pollen grain and egg unite.



Figure 9. Longitudinal section of a flower. (Modified from Free, 1976).

Worker foraging

Nectar, pollen, water and propolis are the four basics required for the honey bee colony to thrive. Nectar is converted into honey and provides a carbohydrate source for energy, for bees as well as humans. Pollen is the protein source for larval growth and development, as well as adult development and maintenance. Pollen also supplies many vitamins and minerals as well as lipids (fats).

Water is of great importance in the colony, making up a large proportion of the larval body weight and being necessary for the proper functioning of tissues and organs of both immatures and adults. Water is used to dilute stored honey and syrup to feed to the brood, and it also plays a major role in temperature and humidity regulation within the hive. Propolis, a composite of resins and gums collected from trees and other vegetation, is used to seal cracks and cover foreign material within the hive.

Whether a worker bee collects nectar, pollen, water or propolis will depend on conditions in the hive at that time, and the task will change with changing colony needs. Generally, the field force works within a three km radius of the hive but can forage at much greater distances if necessary. Inclement weather conditions shorten this radius.

One of the most interesting and important facets of foraging activity is the fidelity of the honey bee to the crop on which she forages. On any one trip, the honey bee will usually visit flowers of only one plant species. It is this characteristic of the honey bee that makes her such an effective cross-pollinator. In fact, given constant conditions and a steady nectar flow, the bee may continue visiting the same crop for several days or even weeks. However, if conditions change in the hive or in the field, the bee may change to another crop, another commodity or both.

The worker honey bee possesses specialized equipment enabling her to gather and carry quantities of nectar, water, pollen and propolis back to the hive. The nectar and water-collecting apparatus consists of specialized mouthparts that come together to form a tube, a muscular "honey pump" in the head to draw liquids up through the tube, a long oesophagus and a honey stomach for short-term storage (Figure 10).

The honey stomach is not part of the digestive tract of the bee, but instead is part of the oesophagus, modified to a thin-walled expandable sac. The forager will visit as many flowers as necessary to obtain a full load of nectar, which weighs about 50 micrograms (1 mg = 1000 micrograms). The numbers of flowers visited per trip will vary from a few to several hundred, depending on the plant species and amount of nectar available per blossom.

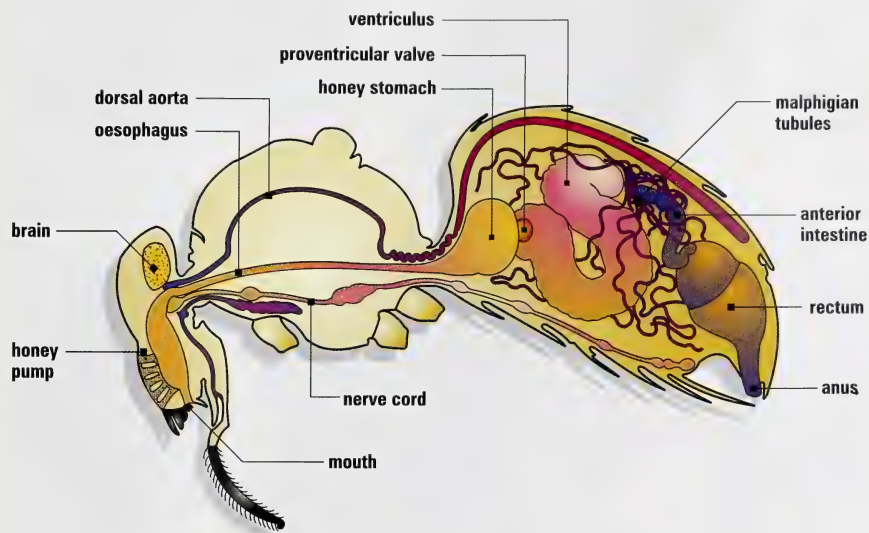


Figure 10. The internal organs of the worker honey bee. (Modified from Snodgrass in *The Hive and the Honey Bee*, 1977).

Honey bees communicate the location and quantity of nectar sources to the other bees within the hive by means of the bee dance. Direction, distance and quality of the nectar source can be determined by the duration of the dance. Thus, other bees may be directed to a food source by a scout bee or forager who returns and performs the dance within the hive, stopping to offer tastes of nectar to potential recruits. It is likely the floral odor clinging to the bee as well as the odor and flavor of the nectar aid in communicating the whereabouts of the food source.

A honey bee collecting pollen only will scrabble at the pollen-bearing anthers of the flower with her mandibles (jaws) and front legs. Pollen grains are often caught in the feather-like hairs of the honey bee as she probes the flower for nectar. These grains are then collected by a series of brushing and cleaning movements into pellets on the hind legs.

The legs of the honey bee are modified to comb pollen from the body and gather it into special baskets for transport back to the hive (Figures 11 and 12). Both fore and middle legs carry brushes of stiff hairs for cleaning pollen from the head and thorax. One section of the hind legs, the basitarsus, has many rows of hairs that can comb the accumulated pollen from the other legs, while another section, the tibia, is smooth and concave with a single hair that pins the pollen load in place. The joint between these two sections acts as a pollen press.

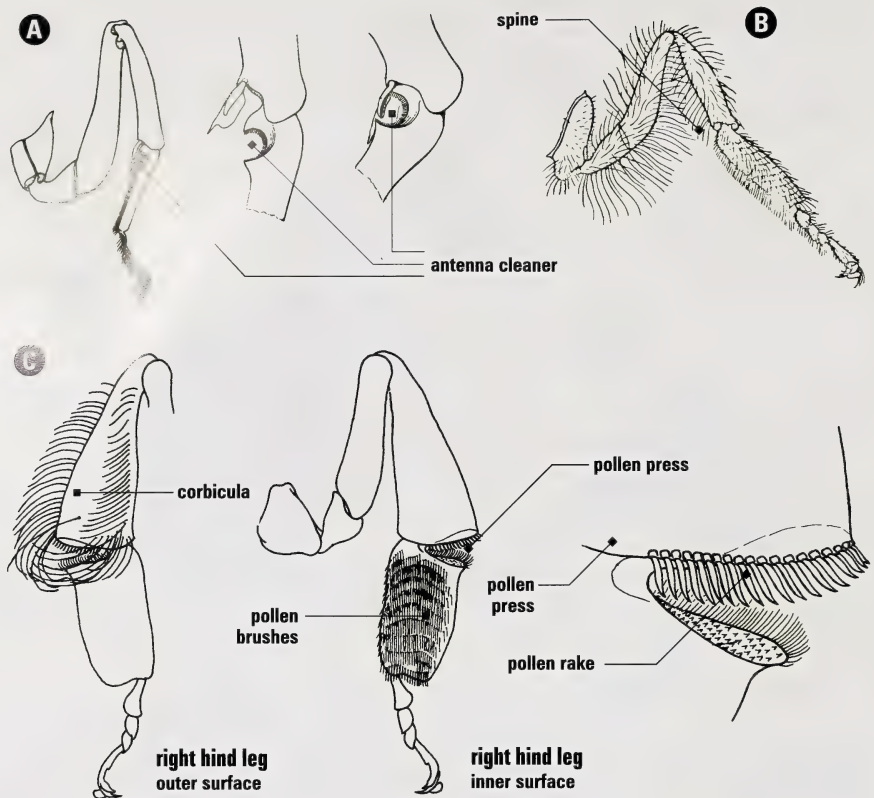


Figure 11. The legs of the worker honey bee. (A) Right foreleg showing antenna cleaner opened and closed. (B) Right middle leg. (C) Right hind leg and pollen basket (corbicula). (A and B modified from Snodgrass in *The Hive and the Honey Bee*, 1977; C modified from Dade, 1977).

Pollen transferred to the combs is worked into the press and then pressed into the pollen baskets or corbiculae, as the concave tibiae are called (Figures 11 and 12). Pollen pellets contain some nectar or honey added by the bee to help stick the pollen grains together.

Each foreleg also carries a specialized antenna cleaner (Figure 11), through which the antennae are drawn to remove pollen and debris. With constant cleaning of the eyes and the antennae, which are the primary sensory organs (Figure 2), the honey bee remains continually able to perceive changes in her environment.

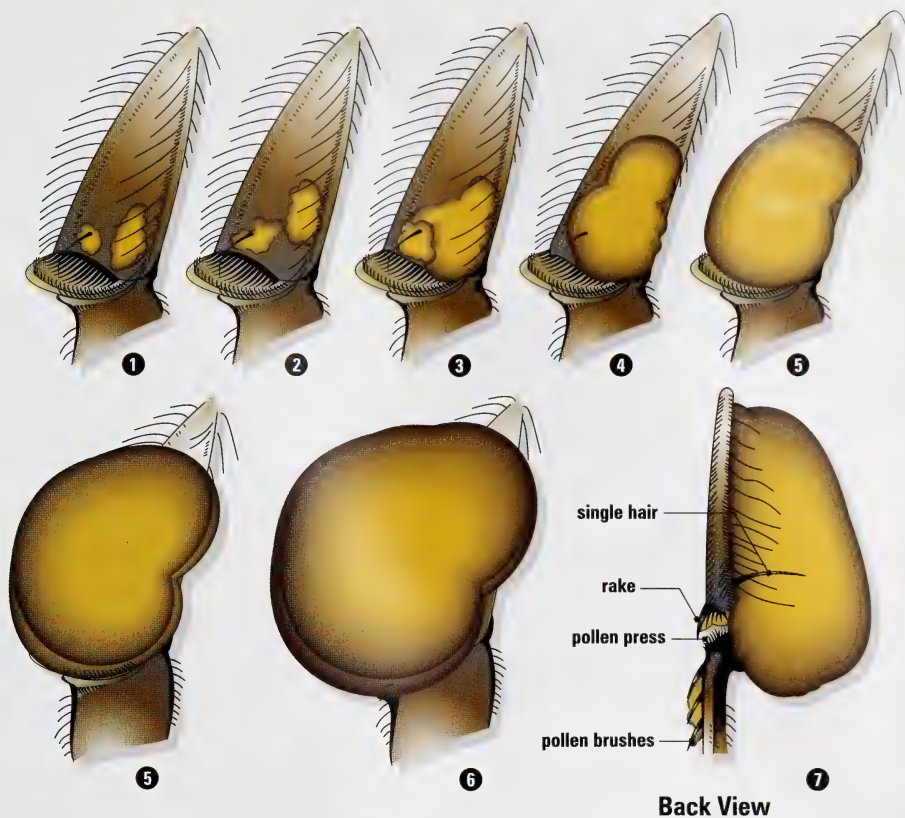


Figure 12. The progressive packing of the pollen load in the corbicula. (Modified from Hodges. 1974).

Food processing and storage

Back at the hive, the field bee will offer her load of nectar to house bees, who then take over the processing, allowing her to go out again. Nectar is composed primarily of the three sugars: sucrose, glucose and fructose, in varying proportions depending on the plant species. Enzymes are added to nectar by both field and house bees that invert the sucrose, changing it to the honey sugars glucose (dextrose) and fructose (levulose).

Nectar contains from 40 to 80 per cent water. Nectar is taken by house bees and placed in cells in a thin film of small droplets with relatively large surface areas. The excess water is evaporated by the continual air movement set up by fanning at the hive entrance. The bees convert the nectar into honey by changing the sugar components and lowering the water content. Once the honey reaches a moisture level of about 18 per cent, it is transferred to storage cells and covered with wax cappings.

If the field bee brings in a load of pollen, she will find an empty cell or one containing some pollen and then dangle her hind legs into the cell. Using the spines on her middle legs (Figure 11) to loosen each pellet, she will kick off the pellets. House bees tamp the pollen into the cell and cover it with a thin film of honey.

Pollen stored in this manner undergoes several changes, noticeably a change in acidity and starch content. It is sometime called “bee bread.” There appears to be no difference in nutritive quality between freshly-collected pollen and bee bread. Bee bread undergoes a fermentation process rather like silage, and this process contributes to its storage life in the comb.

Robbing honey from other colonies

Since the field force is attuned to searching for food, the bees may try “foraging” at another colony when no nectar is available, a situation known as robbing. Robbing bees take on a “furtiveness,” hovering near other colonies, darting away if challenged by guard bees and endeavoring to slip by the guards in search of stored honey. Weaker colonies with few guard bees may be especially preyed upon, and their honey stores may be seriously depleted or completely cleaned out.

Getting Started in Beekeeping

Beekeeping is a fascinating occupation, one that constantly attracts newcomers and stimulates them to try their hand at keeping a few hives. Before becoming deeply involved, however, it is wise to do as much homework as possible:

- local libraries may carry beekeeping texts and magazines.
- the provincial apiculturist's office has many pamphlets on hand that will be sent on request.
- larger towns often have a local bee club that can be a very good source of practical information, as well as starting point for obtaining bees, hives and other equipment.
- an experienced beekeeper may be able to supply bees and equipment and will certainly be able to supply advice.

Although reading about beekeeping will help the beginner gain some familiarity with beekeeping basics, the demonstration of techniques by someone with experience will be invaluable.

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What is Beekeeping?

Beekeeping is the ability to manage honey bee colonies in such a way as to:

1. obtain large (or maximum) adult populations to coincide with the major nectar flows of a given area and
2. utilize this population to the best advantage for collecting nectar and/or pollinating crops.

Three basic problems are common to beekeeping:

- determining when honey flows occur within an area
- building colony populations in preparation for the main nectar flow periods
- deciding what to do with colonies during non-flow periods

These problems must be addressed by beekeepers worldwide, whether they operate one colony or many, if maximum honey production is to be attained. Surveys to determine available bee forage and blooming periods, scale colony records, weather records and a study of farming practices will be necessary in determining honey flows.

Maximum colony build-up depends on good beekeeping practices:

- using good genetic stock
- periodic queen checks
- properly situated apiaries with hives arranged to minimize drifting
- adequate feeding

- disease prevention
- swarm prevention
- provision of adequate storage space for nectar and brood

After the flow period, the decision must be made whether to kill colonies, winter them or winter a proportion of the colonies. If the beekeeper is in an area with abundant bee forage and if weather conditions are favorable for bee flight and nectar secretion, then the beekeeper will be successful in producing a honey crop.

As the commercial beekeeper must manage many hives simultaneously, the apiary site must be managed as a unit rather than as a number of individual hives. This means each hive within the apiary receives the same treatment, such as feeding, queen checks, supering, etc. However, this objective is impossible to attain if population shifts or imbalances occur within the apiary caused by poor queens, disease, drifting, swarming or other management-related reasons.

The Sting

The aspect of bees that horrifies the general public is the tiny piece of chitin called the sting. It is often said the sting is only 1/8 inch long — the other six inches are your imagination. More important than the shock of the initial impact, however, is the fact that a small percentage of the human population is highly allergic to bee venom. The beginning beekeeper should be aware that this possibility of a life-threatening allergic reaction exists.

The first few stings often cause local swelling and itchiness that may last some time. This is a normal reaction. Most people become accustomed to the bee venom with time, but some become more sensitized with each sting. Generalized reactions, where symptoms occur away from the site of the sting, indicate a dangerous sensitivity. These symptoms include constriction of breathing passages, itching and hives, swelling away from the site of the sting, nausea or abdominal cramps, dizziness and confusion and may lead to unconsciousness and anaphylactic shock. If any of these symptoms occur, the beekeeper should seek medical help immediately.

The bee's stinger is made up of a three-piece barbed shaft attached to a venom sac (Figure 13). When a bee stings and flies away, the whole apparatus is usually left behind. Thus when removing the sting, scrape it away with a sideways movement of the thumbnail; grasping and pulling will force more venom from the sac down the hollow shaft into the wound.

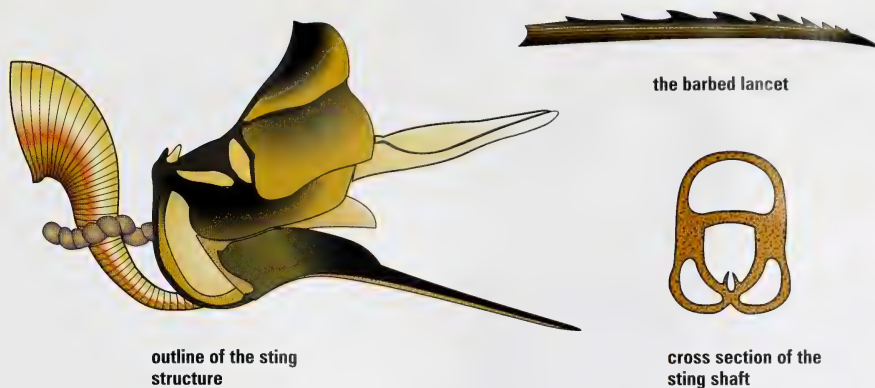


Figure 13. The sting of the worker honey bee. (Modified from Snodgrass in *The Hive and the Honey Bee*, 1977).

Honey bee workers can sting only once and die after doing so. Drones have no sting, while the sting of the queen is not barbed and is used solely against rival queens. The queen can sting repeatedly if necessary.

To avoid more than the occasional sting, the beekeeper should wear smooth, light-colored clothing, preferably cotton and definitely not wool (bees can really grab onto wool, and it will provoke more stinging). Long sleeves and gauntlets, a bee veil tied securely around the collar and pant legs tucked into boots or tied at the ankles will help prevent most stings from occurring.

Purchasing Bees

The beginning beekeeper should generally start with two or three colonies. Having one colony does not allow any comparisons to be drawn, and if the colony becomes queenless, there is no source of fresh eggs for new queen production (see Chapter 11).

To start a colony of bees, the beekeeper may try several options:

- buy a package imported from a producer in another province or country
- buy a nucleus colony (“nuc”)
- buy an overwintered colony from another beekeeper
- hive a swarm of bees

The first three methods are more reliable ways of obtaining bees. The best time of year to begin is the early spring; the beekeeping season begins in April.

Packages or nucs must be ordered some time before April (in January or February), and ordering may be done directly through a club, association or through a commercial beekeeper. Packages are containers filled with 0.9 to 1.8 kilograms of bees. These are filled by shaking worker bees off frames through a funnel into a screened box or tube (Figure 14).

A queen in a screened cage and source of sugar syrup are added, and the packages are shipped bulk to their destination in Canada.

If nucs or overwintered colonies are to be purchased, they should be inspected for any evidence of bee diseases. Regulations vary. In some provinces, provincial inspectors will carry out inspections of all bee equipment for sale, and a permit will be issued if a sale is to be permitted. Find out what the regulations are in your province **before** you purchase any bees or used beekeeping equipment.



Figure 14A.
Tube package.



Figure 14B.
Traditional type package.

Basic Beekeeping Equipment

The basis for the movable frame hive is the “bee space” of 8 mm or 5/16". In a naturally-built (feral) bee nest, the bees leave this space as a passageway between combs. By duplicating what colonies build in nature in man-made hives, we find that the combs are left free from one another and that the spaces between the combs and between the supers are not filled in with additional combs, called burr comb.

This space allows movable frame hives to be intensively managed because their combs are easily removed for examination and manipulation. Thus, the inner dimensions of a modern bee hive incorporate the length and width of comb from feral colonies plus the bee space between and around the combs.

The boxes that make up the bee hive are called “bee boxes,” “hive bodies,” “brood chambers” or “supers.” The name used to describe the standard box depends on its function and position on the hive. The names “hive bodies” or “brood chambers” are typically used to describe the boxes that house the brood nest. The term “honey super” is used to describe the boxes that are “superimposed” over the brood chambers, in which surplus honey is stored.

Most hive bodies and honey supers are of standard length and width (Figure 15) to allow the exchange of frames and boxes from hive to hive. Standard or Langstroth equipment has a higher resale value for this reason. Supers of different depths are available, so the beekeeper can use a shallower honey super for easier lifting, if desired. Equipment of dimensions other than those shown in Figure 15 is also available.

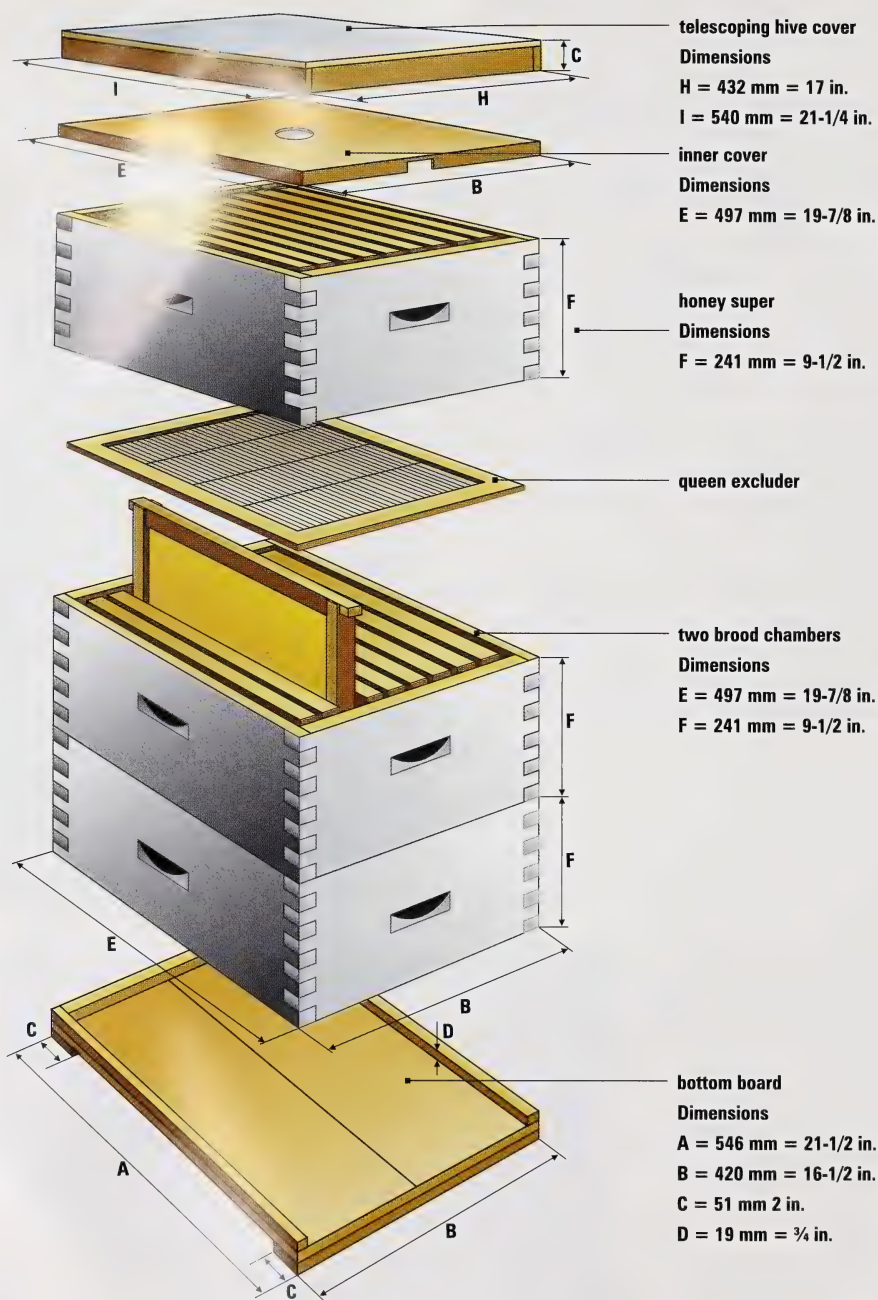


Figure 15. Components of the standard bee hive.

Each Langstroth box, be it brood chamber or honey super, holds a maximum of ten frames, each of which holds a comb of beeswax. Many beekeepers prefer to use only nine frames in their boxes to allow a little extra space for manipulation. Beeswax combs begin as sheets of wax foundation embossed with the bases of the hexagonal cells, about two per centimetre. These sheets may incorporate vertical wires for extra support.

Frames, again of standard dimensions, are cross-wired, and the foundation inserted into slots or grooves in top and bottom bars (Figure 16). Then, the cross wires are embedded into the wax by means of a spur embedder or a weak electric current. When placed in a strong colony with plenty of honey stores or available sugar syrup, the foundation is drawn out and built upon to form a comb.



Figure 16A. Wired frame with embedded foundation.

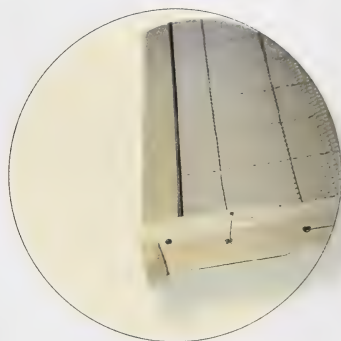


Figure 16B. A wired frame.



Figure 16C. A sheet of plastic foundation.

In general, frames in honey supers hold newer combs that are light or golden in color, while brood chambers hold darker-colored combs. Successive generations of brood in a comb cause this darkening through deposits of larval skins and the polishing of cells with propolis between generations. Dark-colored combs are preferred by the queen for egg-laying, possibly because of greater heat retention properties. Because the production of good brood combs takes time, these combs are a valuable part of the beekeeping operation and should be cared for properly.

Generally, two brood chambers and from three to five honey supers are necessary for each colony. The hive also requires a bottom board and a top cover. The bottom board (Figure 15) should be kept off the ground, either by nailing cleats on the bottom or by placing the hives on pallets or some sort of hive stand to preserve the bottom board from contact with moisture.

An inner cover may be placed over the top box (Figure 15); this rimmed board may have a 5 cm entrance cut from the rim, as well as a 5 cm hole drilled through the cover for feeding purposes. Over this cover is placed the outer cover or hive lid. The telescoping lid is often covered with tin for added protection. These two covers may be amalgamated into one by using 19 mm plywood cut to the dimensions of the supers, with a small hole drilled in the centre and a 5 cm entrance dadoed on one end. Whichever design is chosen, outer covers as well as supers and bottom boards must be painted with two coats of good quality paint for protection against weathering.

The beginning beekeeper may buy used equipment, order pre-assembled new equipment, order it unassembled and assemble it at home or build from scratch. Equipment can be ordered assembled from some beekeeping supply houses, but is less expensive if assembled at home or built from scratch.

If overwintered colonies are purchased, they will be in either one or two brood chambers, and the seller may also supply three or four honey supers for each colony. Beekeepers will often sell used equipment with or without bees. Drawn combs, especially in the brood chambers, are a definite advantage over foundation, but the buyer must be aware of the possibility that the equipment may carry the dormant stages of any number of bee diseases. Again, the permit to sell the equipment, if required in your province, should detail any disease history. Combs should also be inspected before purchasing for general condition, including the percentage of drone comb, mouse or moth damage and broken frames.

Besides bee hives, the beginning beekeeper will find three pieces of equipment essential for colony examination:

- the smoker
- the hive tool
- the bee veil

All three can be obtained through any beekeeping supply house (Figure 17 and Table 2). Without a smoker and a hive tool or suitable substitute, the beekeeper will find any manipulation of super or frame difficult due to propolizing by the bees and the presence of angered guard bees. With a smoker and hive tool, the bees may be kept quiet with a few puffs of smoke while the beekeeper gently pries apart bee boxes and frames to look inside.



Figure 17. Bee veil with hat, smoker, hive tool and brush.

The bee veil protects the head and neck from the worker bees checking out the situation, whether they are angry or merely inquisitive. A pair of coveralls should be purchased for added protection. Gloves may be used while the beekeeper grows accustomed to handling the bees but are not recommended for constant use, as they make manipulation of frames more awkward.

Nearly any type of fuel may be used in a smoker. The aim is to have a constant source of cool smoke. Such fuels as burlap sacking, alfalfa pellets, binder twine, rolls of cardboard and wood shavings are all good fuels. Be sure the sacking or the twine has not been treated with insecticides. A hot smoke may be cooled down by adding some green grass or leaves to the smoker.

Table 2. Equipment necessary to operate a four-colony apiary.

Equipment	Quantity	Item
Hive Equipment		boxes/supers
		metal covers
		bottom boards
		Hoffman frames
		lb foundation – approx. 240 sheets
		lb frame wire
	1	spur embedder
	1	gallon of paint
Personal Equipment	4	sugar-syrup feeders (division board or other)
	1	fume board or four bee escape boards
	1	four-pack winter wrap
	1	
Honey House Equipment	1	smoker
	1	hive tool
	1	veil
	1	helmet
	1	coveralls
Yearly Requirements	1	four frame extractor and motor
	1	electric uncapping plane or scratching fork
	1	storage tank with honey gate – 650 lb capacity
	1	nylon straining cloth
Optional Items	5	packages of bees, 0.9 kg (2 lb) or “nucs”*
	1	package of oxytetracycline, 0.45 kg (1 lb) sugar 40-200 kg (~20-90 lb)
Optional Items	1	bee brush
	1	pair bee gloves
	4	hive stands
	4	queen excluders
	48	frame rests
	1,000	eyelets
	1	eyelet punch
	1	honey gate
	1	strainer
	1	package of fumagillin 0.5 g
	1	pollen substitute 4.5 kg (10 lb)
	1	bee allergy kit “Anakit”
	8	Apistan strips if varroa present
	4	menthol or formic treatments if acarine present
		bee journals

* optional if wintering colonies



The Colony Examination

Colonies should be checked during warm, sunny days with little wind to avoid chilling the brood and bees. Another point to remember is that on days with good flight weather, the field force is away from the hive, reducing the numbers of bees the beekeeper has to work with. During inclement weather, foragers stay at home with nothing to do, and because older bees have a well-developed guarding instinct, colonies will be much more defensive on such days.

Throughout the colony examination, remain calm and unhurried, and keep all movements as gentle and smooth as possible. A “crash-bang” approach only serves to anger the colony and makes checking a chore instead of a pleasure.

The beekeeper should examine the colony with the following points in mind:

1. Are there fresh eggs? Newly-laid eggs generally denote the presence of a laying queen; thus, her presence can be inferred even if she is not seen during each colony inspection.
2. How does the brood pattern look? Check to see if nearly every cell is capped or if the frame has a “spotty” appearance? A “spotty” pattern may indicate that a “poor” queen or a disease problem is causing the death of some of the brood.
3. Does the colony have enough pollen, honey and space?
4. Are there other signs of any disease problems?

The beekeeper should always work from beside the hive so that the entrance and flight path are not blocked. Hive tool in hand and smoker smoking, the beekeeper directs a few puffs of smoke into the entrance(s). The outer cover is removed, placed upside down on the ground and the inner cover, if present, is gently pried up. As soon as the inner cover is lifted, a few puffs of smoke are directed over the top bars of the frame. The smoke has a calming effect on the bees, and if it is used each time the hive is opened, the colony should remain quiet and gentle throughout the season. Without smoke, the colony will become a little more defensive with each manipulation, until the time comes when the guard bees fly up without hesitation to attack the intruder.

If the colony is in two or more brood chambers, the upper chambers are pried apart – again using smoke between the chambers – and are placed diagonally on the outer cover. Starting with the bottom brood chamber, one of the outer frames is gently removed and leaned against the chamber to give room for further manipulations. Each frame is pried apart, removed and examined and then replaced, leaving room to get at the next one. It is important to avoid crushing and rolling bees, because the chemicals or pheromones released by crushed bees alarm the other workers who then become more defensive and apt to sting.

It is not necessary to examine each comb on every inspection or examination of the hive. Inspecting two or three brood combs is usually sufficient to check for brood diseases and will also reveal the status of the queen and food stores within the hive. Take care, especially in the spring, to replace the brood combs in the same order to keep the brood nest intact.

Once the frames have been checked, they are pushed together and the outer frame replaced. The second chamber is then placed back on the first. Each chamber may be

checked in the same manner, again using smoke to prevent crushing bees when the upper chambers are replaced. The inner and outer covers are then placed on top of the hive, and the beekeeper moves on to the next one.

Expanding the Operation

Once the beginning beekeeper has become familiar with bee biology and management, an increase in the number of colonies may be considered. This expansion may be achieved by buying more colonies, by building equipment and buying packages or “nucs,” by splitting colonies or by a combination of these methods. Again, exercise caution in any kind of expansion, be it from two colonies or two hundred. Time and facilities available, suitability of the region and the potential honey market should all be considered. A slow expansion is much easier to handle than an instant tripling or more of colony numbers.

The Apiaries Act

Beekeeping in Canada is regulated in each province under an Apiaries Act (Bee Act) or similar legislation. Each province requires all beekeepers to register with the provincial Department of Agriculture. There is no fee for registration; however, some provinces have an annual registration and identification of apiary locations while others require a one-time registration only, valid for the duration of your beekeeping career.

The Provincial Apiculturist’s function is to enforce the Apiaries Act and to provide extension services and management information. The primary purpose of the Act is to control bee diseases and mites and their spread since these pests spread easily and have a serious, negative effect on bees and honey production. All jurisdictions require hive inspections before sale to ensure the purchaser is not buying hives infected with diseases. Movement of bees infected with mites is regulated in all jurisdictions and restricted in some. Contact the office of the Provincial Apiculturist to determine the regulations in your province and for the latest information on the prevention and control methods for bee diseases and mite pests.

Knowing where beekeepers and their apiaries are located is valuable when widespread aerial spray programs are considered for insect pests, such as mosquitoes or grasshoppers. Beekeepers in areas that may be affected can be notified without delay, so they can protect or move their hives. Government programs such as crop insurance, low interest loans and compensation for bear damage are offered to registered beekeepers only.

Nectar and Pollen Plants

Knowing the nectar and pollen producing plants in an area is an essential part of beekeeping. To quote from Le Maistre's 1943 *Beekeeping for Beginners in Alberta*:

An intimate knowledge of the clover acreage in any given district should be sufficient guide to its suitability for honey production, when due consideration is given to the question of rainfall.

While this quotation does not mention canola or alfalfa, it points to the fact that even with the best management, bees cannot produce honey without a source of the raw materials: nectar and pollen.

While the control of nectar production is, to some extent, genetic, any factor that affects either the day-to-day or long term well being of the plant will also affect nectar secretion. Different plant species have different requirements for optimum secretion. Soil moisture, soil type, precipitation, air temperature and the number of sunshine hours may all affect the quantity of nectar secreted and its sugar concentration. In a drought situation, for instance, fields of canola may bloom for only a short time, and during that time, the quantity of nectar secreted will be minimal; any available water will be utilized for plant maintenance and development first.

Beekeepers refer to a "honey flow" when they see surplus honey being stored in their hives. Perhaps the term "nectar flow" is more apt since it is the nectar that flows from the flowers and is collected and changed into honey by the bees. The nectar flows are generally fairly well delineated on the prairies, whereas in other areas of Canada, such as the west coast, the flows may be less intense and stretched out over longer periods.

There are three nectar flows in most regions of the prairies:

- the spring flow
- the main or summer flow
- the late or fall flow

Honey from the lesser spring and fall flows is usually left for the bees, for spring build-up and overwintering purposes, respectively. The main nectar flow supplies the surplus honey harvested by the beekeeper. Generally, the three nectar flows are accompanied by pollen flows because nearly all the major prairie nectar plants, with the exception of alfalfa, are visited for pollen as well.

The beekeeper should know when the nectar flows begin in his or her area and how long they last. Records of scale colony gains and losses have been kept at Beaverlodge Research Station since 1954. These dates (Figure 18 and Table 3) will give the beekeeper a general

The beekeeper should know when the nectar flows begin in his or her area and how long they last.

idea of what to expect, but allowance must be made for different regions, climatic regimes and cropping patterns as well as yearly variations in weather patterns.

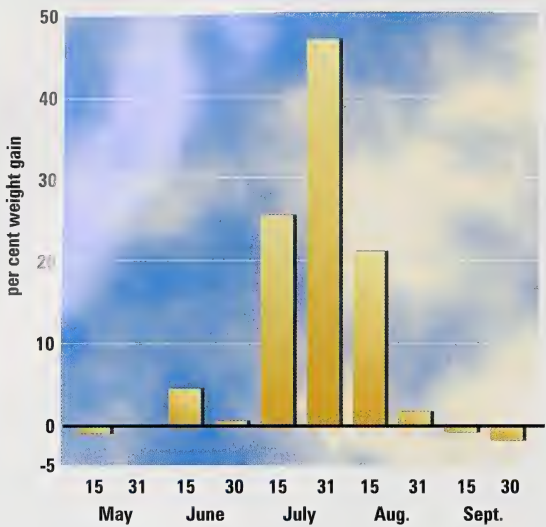


Figure 18.
Scale colony gains,
Beaverlodge 1954-76.

Generally, the spring flow occurs from the end of April to the end of May or mid-June. The main flow occurs from the end of June to the end of July, and the late flow in August and sometimes into September. To know when the flows and dearth periods are occurring, the beekeeper may wish to have a colony on a scale in the home apiary. With periodic scale readings, such information is immediately available, and management techniques can be adjusted accordingly.

Table 3. Records of average nectar flow dates at Beaverlodge, Alberta, (latitude 55° N) from 1954 to 1976. Pollen was obtained from all crops except alfalfa.	
Forage source	Date of nectar flow
Willow	May 10 - June 10
Dandelion	May 27 - June 27
Hawk's-beard	June 1 - Frost
Alsike clover	June 20 - Frost
Canola	June 28 - August 10
Alfalfa	June 28 - Frost
Sweet-clover	June 28 - Frost
Red clover (single cut)	July 10 - Frost
Fireweed	July 5 - August 5

Taken from Henn, G. D. and D. L. Nelson, 1977. An analysis of Beaverlodge nectar flow records. Agriculture Canada Contribution No. NRG 77-6.

Nectar plants may be divided into major and minor categories. Bees collect nectar and pollen from many different plant species, but only a few of these plants grow in enough profusion and produce enough nectar that a surplus of honey may be harvested (Figure 19). As well, nectar production by a particular plant species may vary under different soil and climatic conditions.

Plants considered a major nectar source in one region may be only a minor source in others. Yearly variations may also cause minor honey plants to occasionally yield heavily or major plants to yield poorly. Again, the beekeeper must become familiar with the peculiarities of his or her own region through observation of flowering plants and dates, and weather and scale colony records.



Figure 19A. Dandelion



Figure 19B. Willow



Figure 19C. Canola

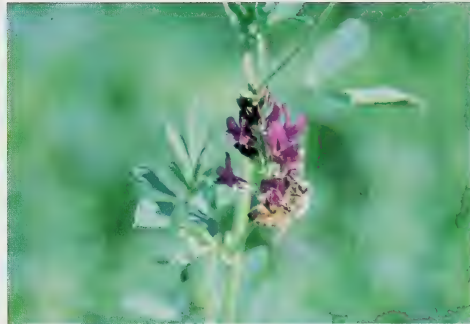


Figure 19D. Alfalfa

Major nectar plants include the following:

- willows and dandelions in the spring
- canola, alfalfa, sweet clover, white clover, red clover, alsike clover, faba bean and sainfoin in mid summer
- sunflower, buckwheat, borage and second blossom alfalfa in the late summer to early fall

Minor honey plants include the following:

- caragana
- pin and choke cherries
- currant
- sow-thistle
- thistles
- fireweed
- hawk's-beard
- saskatoon berry
- raspberry
- aster
- goldenrod
- poplar, elm and other deciduous trees also contribute some pollen in the early spring.

As well, many horticultural crops and ornamentals are good nectar and pollen plants. Apple and other fruit trees, lilac, some of the honeysuckles, poppies and many of the herbs such as borage and thyme, to name but a few, all yield nectar or pollen and are freely visited by foraging honey bees. For the backyard beekeeper, it may even be desirable to plant a "bee garden" to supply the bees with extra nectar and pollen sources.

Each species of plant produces nectar with unique properties that, in turn, affects its value as a honey crop. Characteristics of honey such as its colour, aroma, flavour, sugar composition and speed of granulation are all influenced by the nectar source (see Chapter 7).

Colour is one of the most important factors affecting honey grading and consequently, the price the producer receives for the crop. In general, light coloured honeys such as those produced from clover, alfalfa and canola tend to sell for a higher price when sold in bulk quantities. Darker coloured honeys classed as golden, amber or dark tend to sell for a lower price.

Sunflower and buckwheat, which bloom later in the season, produce golden and dark coloured honey, respectively. Each of these floral sources produces honey with a strong and distinctive flavour that if mixed with the remaining honey crop, will lower colour grade and affect taste, which can lower the price received for the entire crop. Thus, it is often desirable to separate honey from these sources during the extracting process. In some instances, these distinctly flavoured honeys can even be marketed as a specialty and sold at a premium price.

A few plants yield nectar or pollen toxic to honey bees or nectar that, when converted to honey, is poisonous to humans. One case of bee poisoning in the Brooks area of Alberta is documented in the 1935 annual report of the Apiculture Branch. From 50 to 90 per cent of the field bees were lost from affected hives in the apiary during the middle of June that year. The cause of the poisoning was pollen or nectar obtained from narrow-leaved milk vetch, *Astragalus pectinatus*. Fortunately, cases of poisoning are rare; very few plant species in North America may cause such problems. Other plants that produce honey toxic to bees or humans include other *Astragalus* species, mountain laurel (*Kalmia* sp.), rhododendrons and azalias.

Supplementary Feeding

Several times during the year, the food stores in a honey bee colony may run low. Without supplementary feeding at these times, the colony population will decline at least and at worst, the colony will die through starvation.

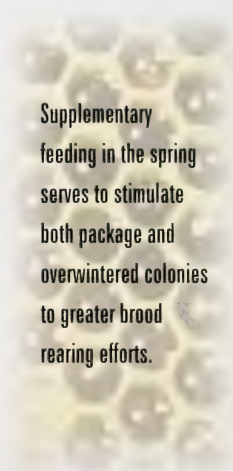
When close to starvation, workers carry larvae and pupae out of the hive entrance and drive drones out. Adults can survive for a short time on their body reserves but will eventually die if food does not become available. A colony that is rearing brood and rapidly building in numbers will go through its honey and pollen stores amazingly quickly. Various authors estimate that a colony should have at least 14-18 kg (about five or six frames) of stored honey on hand at all times during the beekeeping season, should a dearth period occur. The colony should also have stored pollen around the brood area. For the winter, of course, far more honey will be needed.

Carbohydrate Supplements

Supplementary feeding of a carbohydrate will be necessary during the spring for both overwintered and package colonies as well as for new divisions, especially when there is any foundation to be drawn out. By spring, the winter stores are usually much depleted as a result of an acceleration in brood rearing. A delayed spring flow or a spring with much inclement weather preventing foraging increases the need for supplementary feed.

A dearth period often occurs between the spring and main nectar flows, when the dandelions have finished and before the sweet clover and canola begin blooming. At this time, colonies are raising a lot of brood and are rapidly expanding in size. A food shortage at this stage may set them back to the extent they are not able to take full advantage of the main nectar flow. The beekeeper must carefully monitor the food reserves in colonies during the spring brood rearing period.

Supplementary feeding in the spring serves to stimulate both package and overwintered colonies to greater brood rearing efforts. Even if food stores are available in the hive, many beekeepers choose to feed some sugar syrup to colonies for stimulative purposes before the spring nectar flow begins.



Supplementary feeding in the spring serves to stimulate both package and overwintered colonies to greater brood rearing efforts.

Types of feed

Beekeepers feed a variety of sugar types to their bees. Frames of capped honey are certainly the easiest way to feed. Honey should not be extracted from the brood chambers but rather left for the overwintering colonies or used in making up brood chambers for next season's packages (see Chapter 5). Extra frames of honey may be stored over the winter and given back to the bees in the spring when colony stores are low.

Sugar syrup made from refined white sugar is the most widely used supplementary bee feed. Brown sugar and molasses contain a higher percentage of impurities, which are indigestible by bees and may cause a dysentery problem, especially noticeable in wintering colonies. These sugars should not be used to feed bees. White sugar contains almost no impurities and, therefore, makes a better bee feed. The syrup is mixed in a 2:1 sugar:water mixture (by volume) for both fall and spring feeding.

To make small quantities of syrup, use a garbage pail and hand power. For large quantities, a tank with a mixer will be necessary. Hot water is useful in mixing 2:1 sugar syrup, but boiling the syrup is unnecessary and may result in caramelization, making the syrup less digestible for the bees. A colony's food stores will be increased by about 3 kg with 5 litres of 2:1 sugar syrup.

Feeding dry sugar to honey bee colonies is not generally recommended. Bees will consume dry sugar but will also often carry the sugar out of the hive and drop it in front of the entrance. In an emergency, if other means of feeding are not immediately available, dry sugar may be spread on the inner cover around the open feeding hole, so the bees have access to it. Another inner cover may be placed over the sugar to enclose it.

Syrup may be made from honey by diluting it from 17 per cent moisture to about 33 per cent moisture with a quarter volume of water for a 2:1 syrup, or by about a half for a 1:1 syrup. Honey that has darkened through overheating, for instance in a wax melter, may be saved for spring feed but should never be used as fall feed. Overheating causes caramelization and a higher percentage of indigestible matter, as well as the accumulation of toxic substances. If fed in the fall for winter stores, when the bees cannot fly to void their faeces, such honey may lead to dysentery problems within the hive and the premature death of affected workers.

Only honey from colonies known to be free of diseases should be fed back to bees, for disease organisms may be carried in honey and if fed to a colony, may cause an outbreak of disease. Sugar syrup may be mixed with honey syrup to prevent the honey syrup from crystallizing.

Liquid invert sugar is manufactured in two grades, 50 per cent and 100 per cent, primarily for use in the baking industry. Be aware that invert sugar produced by a method called acid hydrolysis is unsuitable for use as a bee feed. With the process known as acid hydrolysis, acid is added to sucrose, which breaks the sucrose molecule into its component parts, glucose and fructose. This process produces substances toxic to honey bees.

Another carbohydrate food that does appear suitable for feeding bees is high-fructose corn syrup (HFCS), also referred to as isomerized corn syrup. This syrup is made from cornstarch by the addition of enzymes, which first break the starch down to glucose and then convert some of the glucose to fructose. HFCS is available in two forms: 42 per cent fructose and 55 per cent fructose. Mixed results have been reported from beekeepers using

Only honey from colonies known to be free of diseases should be fed back to bees.



the 42 per cent formulation, possibly owing to a varying polysaccharide content causing some bee mortality. The 55 per cent formulation appears to make a better bee feed. The moisture content of this syrup is about 23 per cent. The syrup is diluted with water by about a third of its volume before feeding it to colonies.

Although HFCS seems practical as a bee feed, being lower in cost at the time of writing than sucrose, handling problems associated with it make it impractical for the hobby or sideline beekeeper. Since the syrup is shipped by tanker, the beekeeper must have some means of storing large volumes of syrup under heated conditions, preferably over 26°C, as the syrup will crystallize at lower temperatures. The beekeeper must also have a way of liquefying crystallized syrup.

The major problem with HFCS is the potential to cause adulteration of the honey, be it inadvertent or intentional. If HFCS is fed to the colonies in the late spring, the bees may move it directly to the honey frames where it will be mixed with the honey produced at the beginning of the major nectar flow. If using HFCS, take care to stop feeding it to colonies by the beginning of June, or two to three weeks before the main nectar flow is expected to begin, and before any honey supers are added to the hives.

Types of feeders

Whatever type of syrup is used, place it as close to the colony cluster as possible, so it is accessible even during cold weather. The feeder must be readily accessible and must keep the syrup unexposed, because exposed syrup will promote robbing. Before feeding, level the colonies or tip them back slightly so that if syrup leaks, it will gather at the back of the bottom board, rather than running out of the entrance and attracting potential robbers.

Several types of feeders are available:

1. **Hive top feeder** — This feeder (Figure 20) is the same length and width as a super, 10 cm or more in depth and sits directly over the brood chamber. It can be divided in two and has a channel from below to allow bees access to the syrup. A screen can be placed over the access area and down both sides into the syrup compartment, so bees have something to cling to as they feed and do not float away and drown. The standard hive top feeder holds about nine litres of syrup, although some beekeepers may alter the depth so that more syrup can be fed. This type of feeder has some problems with leakage if the joints are not tight, and it takes up a fair amount of storage space. Some bee loss through drowning is common.

Older supers may be altered and used as top feeders if they are adequately braced and lined to prevent leakage. However, substantially more syrup can be fed at one time using other types of feeders, which is an advantage when feeding in the fall. In addition, commercially-manufactured top feeders are available from bee supply firms.



Figure 21.
Division board or frame
feeder. A wooden float
should be inserted to
prevent bees drowning.

3. Friction-top pail — The 13.6 kg friction-top pail (Figure 22) is the most widely used feeder in commercial apiaries. Its size makes it ideal for feeding large amounts of syrup to colonies in the fall or to overwintered colonies needing feed in the spring.



Figure 22.
Feed pails inverted on
hives.
(Photo D. Nelson)

Lids for feeder pails are commercially available and have a rubber ring seal and several holes covered with a piece of 16 mesh/cm (40 mesh/in.) brass or stainless mesh melted into the plastic. Alternatively, the beekeeper may drill several small (1.5 mm) holes in the centre of the lid, or drill several 1 cm holes or a single large hole and melt a piece of mesh into the plastic around the holes with a hot iron.

Once the pail is filled and the lid replaced, the pail is inverted over the hole in the inner cover. Some syrup will drip out until a partial vacuum is formed inside the pail; this syrup should not be allowed to drip onto the ground as any exposed syrup in the bee yard may incite robbing. The recessed lid will allow space for the bees to come up and take the syrup.

The feeder pail may leak when it is heated by the sun, which causes the air within the pail to expand. This result may be prevented by placing a super and an outer cover on the hive

around the pail. Hot syrup tends to run out of the inverted feeder pails, so syrup should be cooled to room temperature before feeding.

In addition, hot syrup will denature antibiotics added for bee disease prevention and control. However during cold weather, bees will take warm syrup much more quickly than cold syrup, so undue cooling is not necessary.

Feeder pails should be stored in a cool, dark place when not in use to prevent deterioration from sunlight. If handled roughly, especially when cold, the lid and rim of the pail will tend to crack. If properly cared for, the pail will last for several years.

Jars with holes punched in the screw-type lids may be used as hive top feeders. Again, the larger the jar, the better, and the jar should be protected from direct sunlight for the reasons mentioned below.

4. **Boardman feeder** — This feeder consists of a wooden block that holds a canning jar and can be inserted into the hive entrance (Figure 23). The feeder allows the beekeeper to see at a glance how much syrup is left to a colony. This type of feeder can be adequate for spring feeding of package colonies. However, there are several disadvantages to this type of feeder:
- as with feeder pails, direct sun may cause leakage
 - in cold weather, bees will not leave the cluster to come to the hive entrance
 - exposure of antibiotics in the syrup to direct sunlight will cause almost immediate breakdown of the antibiotics

Also, colonies that need to be fed in the fall usually require more than can be given in a container of this size, unless the beekeeper is committed to replenishing the syrup as soon as the jar is empty.



Figure 23.
Boardman feeders being
used in indoor wintering.
(Photo D. Nelson)

5. **Outdoor feeding** — To save time, some commercial beekeepers feed each bee yard with a drum of sugar syrup sitting amongst the colonies. The practice is not recommended for several reasons. As mentioned above, exposing sugar syrup to hungry colonies incites robbing behavior. Robbing puts each colony on the defensive, and a yard full of defensive



colonies is not a pleasant place to work. Robbing is also one means of spreading disease among colonies.

Another negative aspect of outdoor feeding is that the strong colonies with a greater foraging force tend to collect more feed, whereas the weak colonies with few foragers tend not to get enough. Thus, the strong get stronger and the weak get weaker while the beekeeper's aim should be to have colonies equal in strength. This outdoor feeding practice also feeds any other colony within foraging distance, be it the beekeeper's colony or that of a neighbor.

Protein Supplements

Pollen, the colony's only natural source of protein and lipids (fats), contains many vitamins and minerals essential to normal bee functioning. As well, pollen contains aromatic compounds that attract bees and stimulate feeding. Protein is necessary to stimulate the hypopharyngeal glands in adult worker bees and for the production of royal jelly by these glands. Protein is also necessary in the development and maintenance of adult muscles, glands and other tissues. Young adult bees normally eat pollen until they are about 10 days old, during which time they are active in feeding brood. Estimates place colony requirements between 18 and 32 kg of pollen per year.

A lack of pollen at any time during the brood production months will lead to a setback in brood rearing and a consequent decline in colony population numbers. This decline will, in turn, lead to reduced honey yields.

Traditionally, spring pollen sources have always been plentiful on the prairies, the earliest flows being from willows and poplars. However, changing agricultural practices and increased land clearing have made good spring locations hard to come by in some regions.

Poor flying conditions may lead to temporary pollen shortages. The period between spring and summer nectar flows may be a pollen dearth period, when the dandelions are finishing and the canola is not yet in bloom. The feeding of protein supplements in times of pollen shortage is a management practice that could be beneficial in some years and should, therefore, be considered seriously by the beekeeper.

Pollen supplements and substitutes

Pollen supplements contain some pollen and some other protein source such as expeller-processed low fat soybean flour, milk powder or brewer's yeast while pollen substitutes contain no pollen. The protein content of pollen is similar to, though somewhat less than that of soybean flour, brewer's yeast and milk powder. Bees can rear brood using these other protein sources, but the advantage of adding pollen is the attractiveness of the resulting mixture to the honey bee. Pollen substitutes may not be utilized in some instances, probably because of the lack of a feeding stimulant.

Whether mixing supplement or substitute, experiment first on a small scale to find a suitable formulation before going into production. The important thing is to find the right consistency, too sloppy a mixture will drip down between the frames while too stiff a mixture will not be used as readily by the bees. It might be necessary to hold back on the liquid portion or to add more dry ingredients to the mixture to correct the consistency.

Supplement and substitute mixtures may be blended by hand or with the aid of a commercial bread dough mixer or drill press.

Once protein foods are given to colonies in the early spring, a steady supply must be maintained until fresh pollen is available. Pollen substitute will be ignored once the bees are able to collect fresh pollen, but there is some indication that straight pollen patties or pollen supplement may actually decrease pollen foraging and reduce the amount of pollen brought into the hive. Feeding pollen supplement should, therefore, be discontinued once fresh pollen is available.

Supplement formulations

Pollen may be fed alone, mixed with sugar syrup or mixed with other protein foods and sugar syrup. Basic proportions are as follows:

- 1 part pollen
- 2 parts hot water
- 5 parts granulated sugar
- 5 parts soybean flour (expeller-processed low fat) or
other substitute

The pollen must be mixed with the water to dissolve the pollen pellets. Add the sugar and stir until dissolved, then add the soybean flour (brewer's yeast or other suitable dry material) and mix into a dough. The relative proportion of the pollen may be increased.

Substitute formulations

Pollen substitutes may be fed to colonies as either a dry mixture or a moist patty. The dry mixture, with or without sugar, may be fed inside the hive, either on top of the inner cover or in a frame feeder, or outside the hive in containers protected from the rain. When the substitutes are fed dry, the bees become dusted with the mixture as they collect it and are subsequently quite easy to pick out both in the air and in the hive.

Because soybean flour and brewer's yeast are not very attractive to honey bees, these products may be mixed with an equal or greater weight of sugar or a 2:1 sugar syrup. One formulation is as follows:

- 3 parts soybean flour
- 2 parts brewer's yeast
- 2:1 sugar syrup

Pollen supplements and substitutes may either be packed into pails or made into patties for subsequent feeding. To form the patties, use a sheet of wax paper, placing the required amount of dough towards one end and folding the other end over, flattening with the hands or a rolling pin. Another method is to form a loaf-like shape with the dough, chill it and cut it into 500 gram slices, placing these between wax paper sheets. Plastic bags may also be used. Patties may be made in advance and frozen until required.

Pollen and disease transmission

If pollen is collected from diseased colonies, it will then act as a reservoir of infection for such diseases as American and European foulbrood and chalkbrood. Oxytetracycline should be fed to colonies being fed protein supplement mixtures as a protective measure against the foulbrood diseases. However, no antibiotic is available to protect honey bees from

chalkbrood. Thus, pollen should be collected from disease-free colonies only, including the foulbrood diseases, chalkbrood and sacbrood.

Caution

Antibiotics must never be fed to colonies using the icing sugar mixture method while trapping pollen for human consumption. The icing sugar/antibiotic mixture can fall into the pollen and lead to pollen contamination, especially if bottom mounted traps are used.

Harvesting and storing pollen

Many pollen trap designs are available, but all involve the same basic principles: the bees must pass through a screen with 5 mm spaces (5 mesh) that knocks the pollen pellets from their legs. The pollen pellets then gather below another screen with 3 or 4 mm spaces (6-8 mesh), which keeps the bees out.

Variations in pollen trap designs include differences in location, size and method of installation. Traps may fit over the front entrance or between the bottom board and first brood chamber. Some traps are designed to keep hive debris and pollen pellets separate. Some traps include cone-shaped drone escapes, as the drones cannot pass through the double screen. Plans for pollen traps are available from the apiculture office. The modified O.A.C. (Ontario Agricultural College) trap is popular and can be further modified to have the pollen drawer open to the rear or side depending on preference (Figure 24).

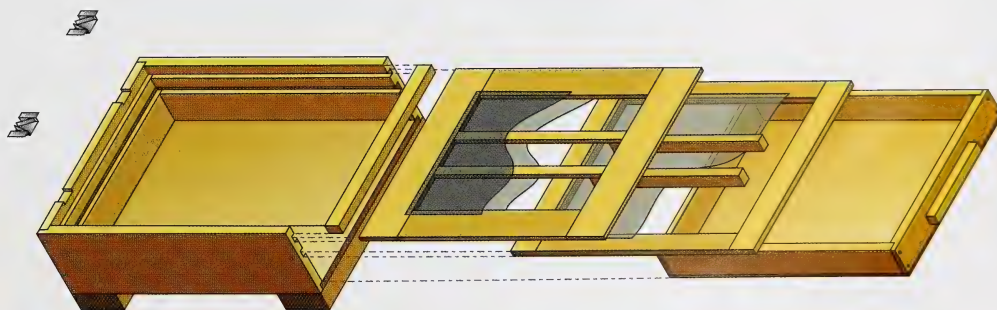


Figure 24. Modified O.A.C. trap.

Whichever design is used, the pollen trap must be weatherproof to protect the pollen. The pollen-collecting container is of wood, often with a bottom of cloth, and/or screening to prevent condensation and mold. Pollen should be collected from strong, disease-free colonies during strong pollen flows (more than 100 grams per day). The pollen collected from one colony over a season can be fed back to up to 50 colonies the next spring in pollen supplement patties. Some honey bee colonies appear to have a genetic predisposition towards collecting pollen, and the beekeeper who intends to trap pollen each year may consider retaining some pollen-collecting stock for this purpose.

Pollen should be removed from the traps on a regular basis and daily during heavy pollen flows or wet weather. Hive equipment must be bee-tight when collecting pollen and all

other entrances and openings closed, as bees are adept at finding alternate routes into the hive to avoid passing through the double screen.

If left on the hives throughout the brood rearing period, pollen traps may cause some reduction in brood rearing and honey yield. Front entrance traps may cause congestion problems during the nectar flow and may interfere with ventilation during hot weather since the hive entrance is restricted by the screens. The double screen may be removed from such pollen traps to ease congestion. In addition, some replenishment of pollen stores in the hive may be allowed. It is best to remove pollen traps before the main honey flow to minimize disruption of honey production and to allow the colony to store as much pollen as possible for their needs and use in the year.

Once collected, pollen must be stored correctly to retain its attractive and nutritive qualities. The best storage method is to bag and freeze the pollen immediately after collection. Pollen stored in the deep freeze will keep its nutritional value for several years.

Another storage method is to mix pollen with half its weight of dry sugar, pack the mixture into containers and cover with a layer of sugar before sealing. This pollen mixture may be stored at room temperature and will retain its nutritional value fairly well. Pollen may be air-dried in a warm room until the pellets are hard and then stored in sealed containers in a cool, dry place. The nutritional value of air-dried pollen decreases with time, so the pollen should be used within two years.

Supplying Water to Honey Bee Colonies

Since honey bees do not store water as they do pollen and honey, a continuous water supply is important to the proper functioning of the honey bee colony. Water is used to liquefy granulated honey and to dilute honey and sugar syrup for feeding to larvae. Without sufficient water, brood rearing is curtailed.

Bees collect water every day and generally visit the nearest source for their supply. They may become a nuisance around stock watering troughs, outdoor faucets and swimming pools if water cannot be found closer to the hive. If water can be found nearby, then less energy is expended by the colony and more foraging time is available for nectar and pollen collection. In the winter, the need for water is diminished, and bees use condensed water gathered on the inner sides and top of the hive.

Natural water sources such as clean puddles, ditches, small ponds and streams are all suitable. If no such source is nearby, drums or smaller containers may be placed in the bee yard and filled with water and flotation devices such as sticks, boards and dried twigs for the bees to land on. Alternative devices include corrugated iron or plastic sheets sloped into a gutter or trough to collect rain water, or a cistern to collect rain water from the roof of an adjacent building. Syrup feeders can be used to keep a continual supply of water in each colony if desired.

Spring Management

Selection of Apiary Site

A good apiary site enables the honey bee colony to maximize its population in time for the main nectar flow. Factors that should be considered in apiary site selection include the following:

1. Hives should be sheltered from prevailing winds at ground level, with southern sun exposure.
2. All-weather accessibility and freedom of flooding are necessary.
3. Grassy or sandy areas retain warmth better than tilled ground. Vegetation in front of the hive entrances should be controlled by mowing or by applying an all-vegetation herbicide (please consult landowner first).
4. Sources of spring nectar and pollen (willow, maple, poplar and dandelion) should be nearby to reduce supplemental feeding requirements.
5. If no natural sources of water are nearby, watering stations should be placed in the apiary. Otherwise, bees may forage for water at livestock watering troughs and swimming pools.
6. If the sites will be used throughout the summer, adequate bee forage must be available. As bees readily forage up to 3.2 km (2 miles), apiaries should be located near the centres of areas that offer a variety of nectar sources.
7. Sites should be large enough to prevent crowding and offer sufficient bee forage.
8. Avoid sites that are easily vandalized. Colonies should preferably be hidden from the view of highways and public roads. Fences, locked gates or private lands are also helpful to deter theft or vandalism.
9. Sites should be free of browsing livestock and bears. Portable electric fences are effective in keeping cattle and bears away from colonies. Further information on electric fences may be obtained from your apiculture office.
10. If several apiary sites are used, it is helpful to locate them so a minimum of travel time and distance are required to visit them. This planning will help keep operating expenses down.
11. Do not select an apiary site too close to someone else's. Try to maintain a distance of several kilometers between apiaries to reduce the risk of disease transmission and forage competition.
12. Register the site(s) with the Provincial Government where required or applicable.

A good apiary site enables the honey bee colony to maximize its population in time for the main nectar flow.



Figure 25. Eight possible apiary layouts.

Apiary Layout

It is important to minimize drift within the apiary. When certain colonies receive large numbers of bees from other colonies within the apiary, problems such as swarming, early supering and disease transmission may occur. Early drifting can be especially detrimental to newly hived packages. These situations will result in reduced colony build-up and loss of honey production for those hives that are losing significant numbers of bees drifting to other hives.

To help reduce drifting and to ensure evenly-populated hives in an apiary, the following methods may be used:

1. Use irregular, non-repetitive hive layouts, facing the hive entrances in different directions, as illustrated in Figure 25. Hives should be spaced 1-2 m apart within each layout for best results. The use of four-hive and two-hive pallets effectively reduces drifting.
2. Use colored hive bodies or colored strips above the hive entrances. Colors such as black, white, yellow and blue are visible to bees.
3. Use existing landmarks such as trees, bushes and fences as orientation cues. When choosing a hive layout, the beekeeper should note the presence or absence of windbreaks, lines of bee flight and equipment accessibility (trucks, fork-lifts, etc.).

Field Records

Keeping field records of weather, dates of nectar and pollen flows, colony condition and management can be a real advantage to the beekeeper. Records allow an evaluation of the quality of apiary sites, such as which sites are prone to stress-related maladies like chalkbrood, when early flows can be expected and which sites are better for wintering.

Such records help in planning colony management and offer valuable information on individual colony performance. Record only pertinent information, accurately and briefly and for several seasons so that good, reliable comparisons can be made. Do not attempt to start collecting highly detailed information that is difficult to maintain or too complicated to be used for future reference. Keep field records simple.

Bulk and Package Bees

Historically, package bees were imported into the prairie provinces every spring from the U.S. After the border closure in 1987, packages of bees could only be sourced from British Columbia, New Zealand and Australia.

Even though Canadian beekeepers have become more self-reliant, packages from off-shore sources continue to be used by beekeepers as a means to offset winter losses, strengthen wintered colonies, expand their operations or to introduce improved bee characteristics. To ensure availability when needed, order packages in January through a commercial beekeeper, a local bee club or directly from a reputable package bee producer or importer.

Package bees are imported and available during the month of April. Prairie producers tend to prefer early arrival and installation dates. When April remains cold, early packages may not build up any faster than later packages. Yet when April is warm and sunny, early packages will have an advantage over later packages in population build-up. Generally for the prairies, packages should arrive no later than the second week of April.

Most package beekeepers order packages containing 0.9 kg (2 lb) of bees, but some order packages with 1.4 kg (3 lb) or even 1.8 kg (4 lb) of bees. The more bees the better because the larger population is less fragile and may need less care, although when conditions are reasonably good, smaller packages may do just as well.

The size of package is a matter of personal preference. If two-queen colonies are planned, larger packages may be better at the start. The number of bees per kilogram can vary depending on the engorgement of the bees when packages are made up. The more sugar syrup, honey or nectar the bees have taken in, the more each bee weighs and the fewer the number of bees in the package. An extra weight allowance of bees should be added by the package producer to make up for this variability.

Preparation for installation

The single-storey empty hives should be prepared and placed at the apiary site before the packages arrive. Each brood box contains nine frames of good brood combs. Frames 1, 2, 8 and 9 should be full of honey (Figure 26), frames 3 and 7 should be full of pollen, and frames 4, 5, and 6 should have empty areas ringed with pollen and/or honey. A frame feeder may replace frame 2 or 8 (1 or 9).

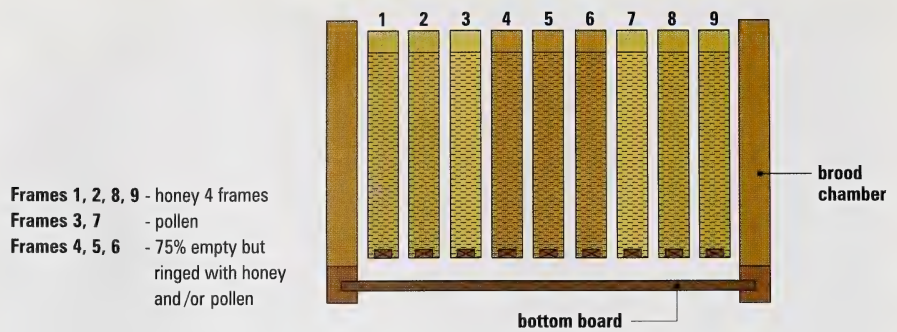


Figure 26. Arrangement of food stores in first brood chamber prior to installing bees.

If honey is not available, sugar syrup must be supplied to the bees immediately upon hiving, especially when hived on foundation. Protein supplement should be given if neither stored nor fresh pollen is available. Blocks reducing the entrance to 2-4 cm should be on the hive entrances.

When the packages arrive, the bees have been in the package container for at least three days. To minimize further stress, the bees should be handled gently and hived as soon as possible. If storing is necessary, packages should be kept in a dark room at about 15°C and may be fed by spraying or sprinkling the screens with warm 1:1 sugar syrup to supply water and carbohydrates for energy. Avoid using a paint brush to apply syrup to the screens as this tool will damage the bees' tongues. Hiving should be done on a cool, cloudy day or in late afternoon and evening, so the bees have a night to settle in and do not immediately fly away and get lost or drift to another hive.

Installation

The generally accepted method of transferring the bees into the hive is as follows:

1. Frames 4, 5 and 6 are removed and leaned against the brood box.
2. The package is knocked sharply on the brood box or other available object, causing the bees to drop to the bottom of the cage.
3. The feeder can and the queen cage are then carefully and quickly removed.
4. The queen cage can be placed in a pocket for warmth while the bees are shaken into the empty hive. Two or three sharp raps and shakes should roll all the bees out of the package container.

Before releasing the queen, check for any damage including missing legs, wings or lameness. She may then be released directly into the cluster by the direct release method. Pour some syrup on her and immediately drain it off, while holding the queen cage just above the bees and prying the screen away. Then watch as she falls into the mass of bees. Queens that have been confined to queen mailing cages tend to be flighty, and the syrup prevents them from taking flight when released. Once the bees start to climb onto the frames from the bottom board, the three frames are gently replaced, and the lid is put back on.

If the weather is warm or the bees are agitated, each package may be sprayed with or dunked in water immediately prior to hiving to slow the bees down and prevent immediate flight.

The queen may be released more slowly by using one of the slow release methods outlined in Chapter 11. Some beekeepers feel a slow release allows the bees to calm down and settle in before the queen is freed, preventing any aggression towards her at the time of hiving.

Once hived, bees can be given medicated sugar syrup for protection against disease and for stimulative purposes, even if feed is not otherwise required.

Follow-up inspection

Five to seven days after packages have been hived (Table 4), the centre frame is briefly inspected for the presence and pattern of eggs. If eggs are present, in a good pattern with one egg per cell, the queen is doing well, and no further inspection is needed. Frames are spaced and the lid replaced with a minimum of disturbance. If no eggs are present, the queen should be found. An apparently healthy queen may be left alone, and the hive marked for later re-inspection. If the queen is injured or missing, a new queen must be introduced using a slow-release method. If not already done, antibiotics and sugar syrup may be given to each colony.

The second inspection is made 10-14 days after the first check. At this time, the brood pattern is again examined on a frame or two, and disease and pest problems are looked for. Colony food stores are assessed and supplemented if required. Oxytetracycline should be given again, as outlined in Appendix E.

On the first or second inspections, failing queens (recognized by spotty brood patterns, a predominance of drone brood, a lack of eggs and young brood or no brood at all) should be replaced. Any supersedure cells (queen cells being built by the bees in their own attempt to replace the existing queen) must be destroyed if the beekeeper plans to requeen, or the replacement queen may not be accepted.

A colony with no brood at all has likely been queenless since hiving. If sufficient bees are present, the colony may be requeened, or if numbers have dwindled, each frame of bees may be shaken in front of another colony needing additional population. If a queen begins to fail late in the season (June, July), the colony will have reduced honey production. At this time of year, the colony can be united with another queen-right colony for honey production. Alternately, the colony can be requeened or allowed to raise its own queen if the hive is to be wintered.

Table 4. Beekeeping sequences and checklist

Visit	Time after Hiving (Package bees)	Purpose	Symptoms	Solution
1	5-7 days	Queen Check Queen-right	Eggs (Do not look for queen)	Close hive
		Queenless	No eggs Roaring sound Bees agitated	Requeen or check again in 3 days
		AFB-EFB prevention		Feed antibiotics
2	3 weeks	Queen Check Queen-right	Brood in all stages	OK
		Queenless	See visit 1	Requeen or unite
		Drone layer	Convex cappings	Requeen or unite
		Supersedure	Queen cell(s) on face of comb	Destroy queen cell(s) and requeen or unite
		Laying workers	Many eggs/cell Eggs on cell wall No queen	Kill colony or dump bees
		Multiple laying queen	Several eggs in bottom of cells	OK
		AFB-EFB prevention		Feed antibiotics
3	4-6 weeks	Queen Check	See visits 1 and 2	
		Brood Pattern Check Good	Frames of brood of uniform age with few cells empty	OK
		Poor	Spotty appearance, brood of different sizes; many cells empty	Requeen or unite
		Food Check Lack of honey	Empty cells Starved bees Bees running over frames "shaking"	Feed syrup or add frames of honey
		Lack of pollen	Presence of eggs and emerging adults but no brood	Feed pollen supplement or substitute
		AFB-EFB prevention		Feed antibiotics
		Space Check Space required	6-8 frames of brood and bees present	Add 2nd brood super
		Space not required	less than 6 frames of brood and bees	Check for space in 1 week check that queen, stores OK and disease-free
4 and others	Every 9-10 days after visit 3	Food Check	See visit 3	Feed syrup or frames of honey
		Swarm Prevention Preswarming-crowded	Queen honeybound No space for eggs "Wall-to-wall bees"	Reverse hive bodies and add a super Provide ventilation
		Swarming initiated	Queen cells on sides and bottom of frames	Check for queen cells every 9-10 days, reverse brood chambers as necessary and add supers where needed. Provide space and ventilation Demaree
		Supering	– Add 1st honey super prior to expected honeyflow – Add others as needed 1 or 2 at a time	
		AFB-EFB prevention		Cease all medication one month before honeyflow

Wintered Colonies – Early Spring

Much of the early spring management of wintered colonies depends on the quality of the previous fall management and the method of wintering (see Chapter 10). Overwintering colonies begin rearing brood in January or February, and honey and pollen consumption increase dramatically with increased brood rearing.

An early spring check is necessary to determine the amount and availability of food stores. This check should be done on outdoor colonies in early March or as early as possible, on a warm sunny day with no wind. The top covering and insulation are removed, the inner cover gently pried up and a little smoke used to keep the bees calm. It is not advisable to disturb the bees by pulling frames from within the cluster.

By looking down between frames, capped honey can be seen. The colony should have from four to six honey frames in contact with the cluster; outer honey frames may be placed next to the cluster if necessary. Protein supplement may be given, and extra honey frames or an inner feeder of warm 2:1 sugar syrup may be placed next to the cluster if honey stores are low. The colony should be closed up and insulation replaced with as little disturbance as possible. Dead colonies should either be removed or closed up to prevent robbing.

Colonies should be checked again for food stores in early April, the protein supplement replenished and honey or syrup given as necessary. At this time, colonies wintered indoors may be moved outside, depending on the weather. Such colonies may have a quick inspection at this point and be fed 2:1 sugar syrup and antibiotics by using pails or inner feeders.

Once the weather has warmed up and pollen and nectar are available, winter wraps may be removed from colonies wintered outdoors; generally, this will be done in the last half of May. At this time, all wintered colonies are subject to a thorough inspection. Bottom boards are scraped and cleaned of all accumulated debris and dead bees. Brood chambers may be reversed at this point (Figure 27) if the upper brood chamber is full of bees and the cluster extends into the lower brood box. Weaker colonies may be left in two chambers or reduced to a single box depending on the number of bees.

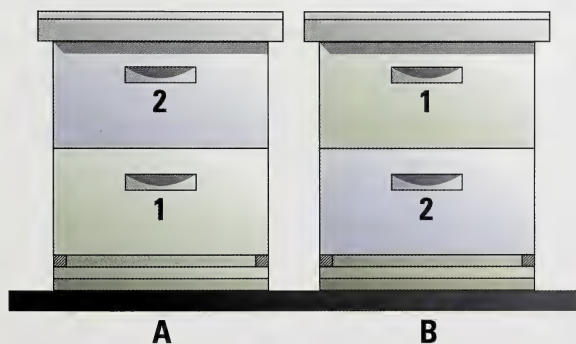


Figure 27.
Reversing brood chambers.
A: prior to reversing.
B: after reversing.

At the same time, colonies are assessed for queen problems, disease symptoms, food stores and strength. A strong wintered colony will have from four to seven kilograms of bees (covering nine to eleven frames) and five or more frames of brood. Dead colonies should be cleaned out and removed from the apiary. Very weak and queenless colonies and colonies with drone-laying queens may be united with medium strength colonies, remembering to pinch off the poorer queen first. The queen's performance can be assessed by checking one or two frames for brood pattern and for symptoms of brood disease. Food stores are assessed, and 2:1 syrup is given to replace depleted stores and to stimulate brood rearing. Oxytetracycline may be given in the syrup or icing sugar, and fumagillin may also be administered when nosema has been detected before.

Checking Colonies

Regular checks should be continued through May and June at 10-14 day intervals. Be systematic and consistent in examining the colonies:

1. How does the brood pattern look?
2. Is there brood in all stages?
3. Are there swarm cells?
4. Are there symptoms of any disease or mites?
5. Are pests such as ants or skunks present?
6. Are there unusually large numbers of dead bees on the bottom board or hive entrance?
7. Does the colony have enough stored honey and pollen?
8. Does it require space for bees, brood and food storage?
9. Are the bees restless and defensive, or are they quiet?

The beekeeper must assess each colony, determine its needs and apply the appropriate management. At the same time, note the general condition of the apiary, including duration of the spring flow and likelihood of dearth periods. In areas where American foulbrood and European foulbrood disease have been reported, colonies may be fed oxytetracycline every 7-10 days. Antibiotic feeding should stop at least three weeks before the start of the major nectar flow.

While checking the brood chambers, cull any broken or misshapen combs or combs with large areas of drone comb and replace with good quality worker combs. Culled combs containing developing brood may be marked and placed on the outside edges of the second brood chamber, or the third box, to allow the brood to hatch out. These frames can then be removed when the honey is extracted and melted down or destroyed. Bottom boards, frames and hive covers should be repaired or replaced when broken or rotting. Keeping hammer and nails in the truck allows for minor equipment repair in the bee yard.

If a robbing situation develops at any time during these inspections, the beekeeper should finish the inspection of the colony, close it up and leave the yard, rather than making the situation worse by continuing to open hives.

Feeding Colonies

Feeding both sugar syrup and protein supplement may be required at times through the late spring and early summer (see Chapter 4). If the spring nectar flow is minor or of short duration, or if there are periods of inclement weather, colonies may quickly become short of honey and pollen during the rapid build-up period preceding the main nectar flow. Feeding of sugar syrup should cease two weeks before the onset of the main nectar flow to avoid adulteration of the honey.

Requeening Wintered Colonies

If colonies are wintered each year, some schedule of requeening every one or two years is advisable. If commercially-produced queens are used, requeening may be done at any time during spring or early summer. If queens are reared by the beekeeper or purchased domestically, the time of requeening depends on when queens can be first made available, usually just prior to the main nectar flow. Methods of requeening are covered in Chapter 11.

Equalizing Colony Strength

Equalizing serves three purposes: it boosts weak colonies, it slows down the growth of strong colonies (which helps prevent swarming) and it makes the hive populations uniform, so the apiary can be managed uniformly. Very weak and queenless colonies may be united with colonies of medium strength or placed above another colony to make a two-queen unit.

To boost the strength of a weaker colony, one or two frames of capped brood are taken from a stronger colony. It is important to shake the bees off and check the frames for disease before they are installed. The transfer of open brood is not recommended, as it merely demands more work for the weaker colony. Closed brood will cause the colony to expand rapidly and offer more bees to help expand the brood nest. If the recipient hive has too few bees to cover the brood adequately, the frames can be moved with adhering bees, or extra bees can be shaken into the hive from the other, more populous hives to boost the colony population.

An alternative method of equalizing is to switch the positions of weak and strong colonies so that the weak colony receives the incoming foragers from the strong colony. Always try to determine why colonies are weak before trying to boost their populations. Disease, mites and old, failing queens can cause colony weakness, and these problems should be remedied before adding bees and brood from strong colonies.

Uniting Colonies

Very weak colonies are often the result of a poor or failing queen. Rather than attempting to requeen such colonies and nurse them back to strength, many beekeepers merely unite them with stronger colonies. If worker brood is present, uniting can be done as follows: the failing queen is pinched off, and the colony is checked for queen cells, which must be removed. A sheet of newspaper is placed over the upper brood chamber of a medium or strong colony, two or three slits are made in the paper with the hive tool, and the weak

To boost the strength of a weaker colony, one or two frames of capped brood are taken from a stronger colony.

colony is placed on top. The bees will gradually chew through the newspaper and form a single unit.

Alternatively, the bees of the weak colony can be shaken in front of a stronger colony and the brood frames added to the same strong colony or another strong colony. Bees shaken in front of another colony will gradually find their way inside without major conflict.

If no brood is present in a weak colony, the bees can be shaken off all the frames in front of another colony. Any extra honey and pollen frames may be given to colonies in need of food stores. Before uniting colonies, the weak colony should be checked carefully for evidence of any brood disease, as diseases can be spread by both brood frames and adult bees.

Dividing Colonies

Dividing strong wintered colonies is one method of slowing their build-up while increasing colony numbers, either to make up for winter losses or to expand the beekeeping operation. There are several ways to split colonies. Most often, a new colony is made from either a strong single-parent colony or from a two-parent colony. Dividing a colony in two may result in two weak colonies. Generally, the parent colony should not be reduced so much that it can no longer make a full honey crop.

Some commercial operations have adopted a different method of making up colony losses or for producing divisions for resale. Healthy parent colonies are selected and divided into whatever number of splits or nuclei they can produce, each the size of a two to three pound package. Outside queen sources are needed in early spring to provide each nucleus with a queen. When divisions are made later in early summer, self-raised queens can be used.

The splitting of a healthy colony to depletion seems destructive, but there are some distinct advantages. There is generally much less labor involved compared to applying a single split to each parent colony. The splitting-to-depletion method seems helpful in keeping down tracheal mite infestation levels and allows for effective varroa mite control applications.

In preparation for spring colony division, queens must be ordered ahead of time to be on hand sometime in May. Divisions are made once the weather has warmed and the risk of frost is low. If the divisions are made to replace winter losses or to expand the operation, the division should not be too late; otherwise, no honey crop can be expected from these colonies. The first offspring from the new queens will be foraging about six weeks later, so the expected dates of the major nectar flow must be kept in mind when making divisions. If the time span until the start of the main honey flow is short, splits may be made stronger to allow for a shorter build-up period.

A warm, sunny day with no wind is best for this colony division. Queens and brood chambers with bottom boards and covers for the expected number of divisions are brought to the apiary. Brood chambers should be made up with honey and pollen frames as for packages. If possible, an inner feeder of warm 2:1 sugar syrup may take the place of one frame.

The queen in each parent colony is found and placed to one side. One or more frames of capped brood and adhering bees are taken from each parent colony, checked for disease and

placed in the new brood chamber. A frame of honey and pollen may also be transferred if the parent colonies have a surplus.

The new division ends up with three or four frames of bees and brood, most of which is capped. Parent colonies receive empty combs and their brood nests are consolidated. Two or three frames of extra bees may be shaken into the division to strengthen it. These bees will make up for the field bees that fly back to the parent colonies when divisions are left in the apiary. A new, caged queen is placed in the division after she has been visually checked and all attendant bees removed. A slow release method is employed for the queen (see Chapter 11).

If the divisions are to be moved to a new location, requeening should take place after the move because of better queen acceptance and lower risk of accident. It is generally recommended to move new divisions to another apiary site to avoid the drifting of bees back to the parent colony. If moving is not possible, the divisions should be set down away from the parent colonies and oriented in a different direction. Entrances should be reduced to slow the flight of the bees and allow them to orient to their new location.

Alternatively, the new division may be placed temporarily on top of one of the parent colonies over a solid inner cover, with a 5 cm entrance in the rim facing towards the back loosely plugged with grass. Thus, the division can take advantage of the heat from the colony below until it gains some strength. It may then be set down when the parent colony receives another super. Robbing of these small colonies can be a problem, so equipment should be bee-tight and the entrance size reduced.

Divisions may also be made without searching for the queen. This method is useful when many divisions are made or when preparing two-queen hives. The parent hive is inspected and three frames of capped brood are selected. The bees are shaken off the frames and placed in a brood chamber with supporting frames of honey pollen and empty comb. The frames removed from the parent hive are replaced with empty comb. A queen excluder is then placed on the parent hive, and the division is placed on top.

The bees will quickly move up to cover the brood frames in the division, but the queen will not be able to pass through the excluder. In 30 minutes or so, the division can be placed on its own bottom board and possibly moved to another apiary, or the excluder can be replaced with a solid inner cover as above if two-queening is the object. A new queen is then introduced to the new division as before.

These new divisions are useful in requeening strong colonies that have been made queenless before the main nectar flow. These colonies are then provided with a young, laying queen. The division may be united to the queenless colony using the newspaper method. If divisions are made solely to produce laying queens for requeening of wintered colonies, one can wait until the beginning of June (see Chapter 11).

An alternate method of increasing colony numbers for next year is to make up nuclei (nucs) that are not intended to produce a honey crop within the same season, but that have time to build up to good wintering strength by September. Nucs are made up in the first part of June, and timing is critical to their successful build-up. Two or three frames of capped and emerging brood and adhering bees are placed in a separate brood chamber and given a queen; the nuc is then set aside from the parent colony and is fed syrup and protein supplements, if needed. The hive equipment should be bee-tight and an entrance reducer in

place to prevent robbing. By September, these nucs will have built up to a colony filling two brood chambers, and they may even produce surplus honey some years. This method allows for the production of one's own stock or of locally-purchased queens or queen cells when quality and availability are high.

This method of producing nuclei, intended as honey producing colonies in the following year, has been adopted successfully by many commercial producers. The nuclei can receive appropriate mite control applications at any time of the season since no honey is being produced for harvest. Wintering nuclei has proven much more cost effective than wintering full size colonies because of lower demands in equipment, sugar-feed and medications. Extra numbers can be made up in anticipation of winter colony losses. These wintered colonies will be strong enough to produce new splits in the second year and produce a honey crop.

If colonies are wintered indoors, nucs may be made at the end of June, thus taking advantage of brood that will not be old enough to be collecting much nectar during the main flow. Nucs made up at this time may not build up to more than one brood chamber in strength and may not be strong enough to winter well outdoors. However, both nucs and single-storey colonies can be successfully wintered indoors.

If spring yards are not suitable for summer use, summer sites should be found well before the main nectar flow is expected.

Moving to Summer Apiary Sites

If spring yards are not suitable for summer use, summer sites should be found well before the main nectar flow is expected. Sites should be selected for good honey production from year to year, taking advantage of variations in weather, soil and crop conditions. Field records from previous years will indicate which areas traditionally yield well and when flows can be expected. Some areas can change drastically from year to year because of changes in crop plantings.

Summer site requirements are essentially the same as those for spring sites:

- all-weather accessibility for vehicles
- some shelter from the wind
- enough room for all colonies
- arrangement of sites to minimize travel time
- adequate water supply
- good summer nectar flows
- low visibility to reduce disruption
- free of browsing cattle and bears. An electric fence is an effective deterrent and essential in keeping bears out of the apiary. Select sites not visible from roads and highways, to reduce the risk of vandalism and theft.

Honey bees forage up to about three km from the hive with little loss in honey yield. When two different blooming crops are located five km apart, the summer yard should be located halfway between them rather than beside one or the other. When both fields have the same blooming crop, select the site with the best bee forage potential.

If possible, package colonies should be moved to the summer sites while still in one brood chamber. Once second and more supers have been added, it becomes more difficult to move the colonies. Depending on local conditions, colonies are generally moved in May,

preferably at dusk or at night when all bees are inside and the temperature is lower. Entrance and top screens are not required for short moves at night.

Some beekeepers fasten bottom boards permanently to the first brood chambers with two hive staples on each side, slanted in opposite directions. While helpful for moving, permanent fastening makes reversing brood chambers and cleaning bottom boards difficult. Another fastening method is to have nails protrude through the bottom board rim into the brood box. This method prevents lateral movement and allows easy removal of the brood chamber from the bottom board. Other producers do not fasten the supers onto the bottom boards, but remove the lid and stack the hives so tightly together on the truck that no lateral movement can take place. Each row of hives must be securely strapped and fastened to the deck.

Before lifting the hives, direct several puffs of smoke into the entrance to keep the bees from flying out. Hives should be loaded with the frames parallel to the truck so that rocking is minimized. Frame spacers or self-spacing frames prevent the problems of frames sliding together or falling from the frame rests. Without spacers, frames 4, 5 and 6 may be fastened in place with nails driven through the hand-holds (left protruding for easy removal). Hives are tied in place on the truck to avoid shifting in transit. Once the hives are unloaded at the summer site, hive entrances may be lightly stuffed with grass to slow down the foragers and allow for orientation.

When colonies are moved less than three to five km, field bees often return to the old site. Try to move colonies to new sites at more than five km distance. Hives moved a short distance, across the back garden for example, should be moved a little each day so that returning foragers can find their home.

For daytime moves in hot weather, use top screens to allow ventilation and clustering space for the bees. These are boxes about 10 cm in depth, screened on the top, with cross supports on which bees may cling. For the entrance, a stiff mesh with 4 mm spaces or smaller can be cut for the full width of the entrance and about twice the height. When the screen is folded lengthwise and pushed into the entrance, the screen will hold itself in place. All cracks between supers should be plugged or taped.

Apiary Maintenance

In the summer apiary, vegetation in front of each hive should be controlled so that the bees have easy access to the hive entrance. Mats of cardboard, sugar sacks cut in half, tar paper and the like may be placed in front of each hive and anchored under the bottom board. Alternatively, vegetation may be treated with herbicide around each hive. Herbicides are very effective when applied to young vegetation early in the season but should not be used later when the bees are flying. Soil sterilants and herbicides with long residual properties are not recommended, as they may have undesirable effects on non-target vegetation such as the trees surrounding the bee yard.

Mowing with a cutter or motorized weed-eater is very effective and does not leave residues. When using motorized mowers, take care to smoke all the hive entrances before starting to mow; otherwise, vibrations through the ground may result in a severe defensive response. Sites should also be checked for short stumps and debris hidden in the grass.

Broken frames and bits of comb should be collected and removed from the yard after each visit.

Space Requirements and Supering

Beekeepers have traditionally allowed a total of five bee boxes per hive. While this number was probably sufficient for package colonies, more boxes are needed for wintered colonies in most parts of the prairie provinces. Three brood supers and three or four honey supers, for a total of six or seven per hive, may be needed to optimize honey production.

Outdoor wintered colonies are generally wintered in two brood chambers. Both chambers are usually full of bees and brood by the end of May, by which time the winter wrap has been removed.

When there are five or six frames of brood in the second super, and before it becomes plugged with honey, a third box, made up with nine empty combs, is added to each colony. This step generally takes place by the middle or end of May for wintered colonies and a month later for packages. Entrance reducers can be removed from the colonies around the beginning of June. Timing varies from year to year and yard to yard, so it is important to check the colonies regularly.

Package colonies with good prolific queens can generally receive second brood chambers five to seven weeks after hiving or in the latter half of May. These colonies should have five or six frames of brood and from seven to nine frames of bees at this time. Seconds should contain nine dark brood combs with pollen and honey arranged in the same manner as in the first, if possible. If the bees are slow to move into the seconds, one or two frames of capped brood may be placed in the centre of the second to draw them up; this baiting must be done when boxes of foundation are given. If colonies are not yet strong, and the weather is cold, the seconds may be placed underneath the firsts to provide extra space without dissipating cluster heat. Brood chambers may then be reversed as required.

Honey supers contain nine frames of honey comb, preferably light in color since dark comb may darken the stored honey. Combs that have had one or two cycles of brood reared in them are ideal for honey storage, being light in color but strengthened by cocoon residues and propolis. Newly-drawn combs must be extracted with care, as they are easily broken.

Both bottom supering and top supering are practiced by beekeepers, although most commercial beekeepers prefer top supering for speed. Top supering necessitates getting the supers on before a honey barrier is formed, thus good timing is imperative. Bottom supering means far more work, lifting partially-filled supers to place empty supers beneath, but is necessary if the supers are plugged and the beekeeper does not wish to extract them right away. In addition, unless queen excluders are used, the queen may move into empty supers placed above the brood nest.

Frame spacers are often used in brood chambers and in honey supers. The use of spacers saves time when supering colonies and makes the use of self-spacing frames unnecessary. Disadvantages of spacers include the loss of lateral frame mobility when checking brood chambers and the loss of the correct bee space between combs. Metal spacers corrode quickly and rust when formic acid is used to control mites. As such, these spacers require frequent replacement.



When the main honey flow commences, colonies need plenty of space. Bees need space to cluster, for wax-builders to hang, for temporary storage of unripe honey, as well as for brood rearing and the storage of pollen and honey. Even more space is required when temperatures and humidity are high during heavy nectar flow. When the hive becomes full and no space is left to process and store nectar, the field bees stop foraging. In regions of short, intense nectar flows, such slowdown or temporary stoppage may mean losing the opportunity for a great honey crop.

When in doubt, give more space. It is better to be too early and risk “stove-piping” by the queen (moving upwards through each box rather than expanding the brood nest laterally) than to be too late and risk swarming and reduced honey production.

White ridges of wax appearing in the top of the uppermost brood chamber is a signal for supering. In the prairies, where nectar flows are intense and of short duration, the honey production and storage requirements may get ahead of the wax building, and whitening of the combs is, therefore, not a reliable cue. Supering should be considered in combination with anticipated nectar flow, frequency of visits and strength of colony. Generally two or more supers are added just prior to or at the beginning of the main nectar flow, and more are given as the flow progresses.

When the hive becomes full and no space is left to process and store nectar, the field bees stop foraging.

Drawing Foundation

Each year, some brood combs are lost through breakage and culling, and these combs must be replaced with good worker combs from the honey supers. To replace combs in the honey supers, the beekeeper may give each colony up to nine or ten frames of foundation with only a minor reduction in honey yield in a good year, although in a poor year, it may be difficult to get colonies to draw out as much foundation.

If at all possible, colonies should never be given whole boxes of foundation, for such supers will act to some extent as a barrier to upward expansion, and some colonies will show great reluctance to move into them. It is far better to intersperse foundation amongst drawn comb, beginning with three frames in the third super. If supers of foundation must be given, each should contain ten frames instead of nine. Nine frames of foundation leave enough space between frames that bees may construct burr comb instead of drawing out foundation. The bees will work on the centre frames first, so outer frames may be rotated inwards during each subsequent visit.

Foundation will only be drawn out during a nectar flow or while feeding a 2:1 sugar syrup. Otherwise, bees will ignore it or chew holes in the foundation sheets.

Use of Queen Excluders

Queen excluders are used to confine the queen to the brood chambers. Most often, the excluder is used between the second brood chamber and honey supers. For two-queen colony systems, this piece of equipment is essential.

When the excluder is installed, the bees should be encouraged to overcome the barrier. The third super should be given before the second is plugged with honey. To encourage the bees to move up into the third super, it must contain drawn comb. Placing one or two

frames of emerging brood and adhering bees in the third super is very effective in stimulating the bees to pass the excluder. Placing a super containing only foundation on top of the excluder should never be done because the excluder and the foundation will then function as a double barrier, and the colony may end up swarming instead of expanding.

Two-Queen Colonies

While there are probably as many variations in making up two-queen colonies as there are beekeepers, the aim remains the same for all systems: to maximize adult bee populations in preparation of the main nectar flow. By managing two queens in one colony, the colony can expand very rapidly, resulting in a greater ratio of field bees to house bees and hence, the greater the colony's foraging capabilities.

Two-queen systems also offer better swarm control and requeening of wintered colonies. As well, extra laying queens are available for those colonies with queen problems during the spring and summer.

The disadvantages of two-queen systems include the increased labor and equipment as well as the cost of the extra queens. Two-queen colonies require precise timing in management and demand greater equipment manipulation. In some areas, two-queen colonies can reach a height of nine or ten supers requiring solid footing. As queen excluders are used throughout the nectar flow, honey removal requires bee-escape boards or bee-blowers (see Chapter 6).

For the prairie provinces, where two-queen colonies are most suitable because of the short but intense main nectar flow, units are usually made up from wintered colonies sometime in May. The timing depends on colony strength and the strength and duration of the spring flow. Two-queen colonies are at their peak from eight to nine weeks after being made up. For two-queen units made up from packages, nine or ten weeks may be required for build-up.

When making up two-queen units, the parent colonies should be equalized to similar strength by an exchange of adults or capped brood. Then, the original queen in each colony is placed in the bottom brood chamber with younger brood, food stores and empty comb. The other two empty brood chambers may be placed in the second and third positions with a division board in between. Such a division board is generally an inner cover with all the feeding holes completely blocked, turned so that the entrance is in the upper rim and facing the opposite direction from the lower entrance (Figure 28). This initial complete separation is necessary; otherwise, the odor of the first queen remains throughout the colony and may prevent acceptance of the second queen.

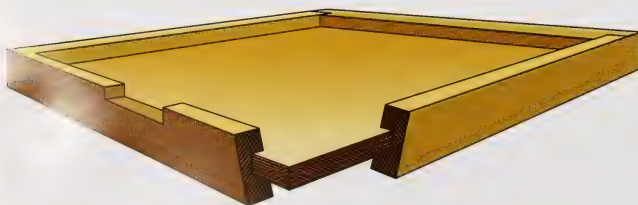


Figure 28. Solid division board used in initial step in making up two-queen colonies. The top entrance should face the back of the hive.

Capped brood and plenty of honey are placed in this top brood chamber, and two or three frames of extra bees shaken in to make up for subsequent drifting back to the lower entrance. A new queen is given to the upper unit using a slow release method. The lid is replaced and the upper entrance loosely blocked with fresh grass to allow time for orientation. Equipment must be bee-tight to prevent robbing and to improve queen acceptance in the top unit.

If the original queen cannot be found or if the beekeeper does not wish to search for the original queens, a queen excluder may be placed between brood chambers and each chamber checked in four days for eggs. The chamber containing the queen is then placed on the bottom and the two-queen units made up as above.

Both units are checked a week later for laying queens and signs of swarming or supersedure. Queenless units may be requeened or reunited. Division boards of queen-right colonies are replaced at this time with an apparatus known as a two-queen board, which is comprised of an entrance in the rim as well as two layers of zinc excluder material, so air and bees move through but queens do not meet.

Alternatively, division boards may be replaced with a single queen excluder, using a sheet of newspaper to slow the mingling of the bees and allow for acceptance to both queen odors. An upper entrance is made by offsetting the second unit forward over the excluder. Bees can then move freely from one unit to another without hostility. The upper queen is usually given another brood chamber, while the lower queen is restricted to one. If required, supers are provided to both units. If two brood chambers are given to either queen, periodic reversal of the chambers may be needed.

The brood chambers of each unit are brought together at the beginning of the main flow, just prior to the first pull. At this time, the beekeeper may either reunite the units or continue to keep them separated by means of a single excluder. Uniting the units will usually cause one queen to be killed, thereby reducing the amount of brood to be fed.

If two-queen colonies are used as a method of requeening, the old queen may be found and killed to ensure the survival of the younger queen. An excluder is generally left between the brood chambers and honey supers for the duration of the flow. After uniting, colonies are managed as single-queen colonies with a much higher population, greater space requirements and higher honey yields.

Swarming

As mentioned in Chapter 1, swarming is the colony's means of reproduction. Capturing swarms is one method of increasing the number of colonies in a beekeeping operation. In many countries, swarms are routinely hived or attracted into hives and the honey subsequently harvested. However, relying on swarms for colony increase has its drawbacks:

- Firstly, while nearly any colony will swarm given the right circumstances, the hiving of a swarm may be a perpetuation of a swarming strain rather than a selection away from swarming.
- Secondly, the beekeeper is not in control of making the divisions and requeening them, so the quality of the stock may suffer.

- Thirdly, it is the strongest colonies, which would otherwise produce a good honey crop, that do the swarming.

Swarming reduces colony strength too close in time to the main nectar flow and, thus, decreases the productivity of that colony.

Before swarming takes place, a slowdown in egg laying and foraging occurs as the bees get into the “swarming condition.” Even if the colony is prevented from actually swarming through some corrective action by the beekeeper, it will be less productive as a result. Management techniques are best employed to prevent the swarming impulse from occurring rather than trying to control it once it has been initiated.

Swarm prevention

The most important factor in swarm prevention is the supply of adequate space when needed. Bees need space to sit, especially during inclement weather when the foragers are confined to the hive. Inadequate space for processing and storage of honey means the brood nest becomes honey-bound, and the queen no longer has sufficient room for egg-laying. A queen prevented from egg-laying produces less queen substance, which reduces colony cohesion and may lead to swarming.

A failing queen also produces less queen substance, and if a supersedure is underway at this time of year, the colony may issue a swarm. Colonies should be requeened regularly to help prevent both supersedure and swarming. The brood nest should be kept free of congestion by reversing brood chambers and adding supers.

High temperatures and humidity, poor ventilation and air drainage are all factors contributing to the development of the swarming impulse, each relating to the need for space. Space requirements per bee increase with temperature. Poor ventilation leads to high humidity when excess moisture is being evaporated from nectar, thus increasing the need for space to spread out the nectar.

Temperature and humidity problems can be solved to a large extent by providing more space, removing entrance reducers, providing entrance mats and cracking lids or supers, setting them ahead slightly to allow more air flow. Foundation and queen excluders should be used judiciously so as not to form a barrier to upward expansion. Honey-bound colonies should be bottom supered. Populous colonies may be used in areas with an early main nectar flow to keep the bees busy at work instead of planning to swarm.

Some colonies have a genetic propensity for swarming and may swarm regardless. These colonies should be culled from a wintering operation. Colonies raised from packages appear more inclined to swarm than wintered colonies.

Swarm control

Notwithstanding management efforts, a colony may still enter a swarming condition. There are several ways of preventing bees from actually leaving the hive. From about mid-May onwards, regular hive inspections should include looking for queen cells that will indicate swarming initiation. A quick examination method is to crack the brood chambers with the hive tool, pull the second chamber a little forward and tilt it back, smoking the bees on the bottom of the frames so that they move up.

Colonies should be requeened regularly to help prevent both supersedure and swarming.

Swarm cells are generally located along the bottom and sides of brood frames, usually at different stages of development. Queen cups (Chapter 11) should be checked for eggs and young larvae. Queen cells containing older larvae and pupae are drawn out and are easily distinguished (see Figure 51). If swarm cells are found along the frame bottoms, they should be crushed, and the colony should then be checked thoroughly for any cells elsewhere on the frames. At the same time, extra space and means for ventilation must be provided to relieve brood nest congestion. Swarm cells must be removed every nine or ten days to prevent the occurrence of swarming. If the colony is left longer than ten days with swarm cells, the old queen may depart with a swarm, leaving the colony with several virgin queens on the point of emergence.

The Demaree method is effective for arresting the swarming preparation of a colony. This method involves confining the queen to one frame of brood in the bottom brood chamber along with eight empty combs. An excluder is placed on the brood chamber, and an empty honey super placed above it. The rest of the brood is placed on top, with capped brood in the third position and open brood above that. The top boxes are checked about a week later to destroy any queen cells. The brood nest can be consolidated when the main nectar flow begins.

Beekeepers often clip one wing of mated queens, both to mark her and to help in swarm control. This operation will slow swarming but will not prevent it; the bees will still leave the colony but will return when they discover the queen is not with them. The bees will wait until a virgin queen emerges and then swarm. Clipping wings is a delicate operation, requiring time and a gentle, steady hand. Virgin queens should never be clipped because of the need to fly and mate.

Handling swarms

Most swarms occur between 11 a.m. and 3 p.m., when temperatures are highest and enough daytime hours are left. Swarms often occur on the first sunny day following a period of inclement weather, and they usually settle in a nearby tree or other object until a new site has been found. The swarm then leaves its temporary location.

Swarms may be reunited with the parent colony or used to establish a new colony. To hive a swarm, you need a brood chamber with bottom board and cover. Sometimes swarms, depending on location and circumstances, are easily shaken into the brood chamber. If the queen is shaken into the box with the bees, the swarm will usually settle into its new-found home. If she is not, the bees will fly out of the box and back to the original location to rejoin the queen.

If the swarm is not easily accessible, it may be necessary to use some other container to collect the bees and then dump them into the brood chamber. The key to success is to hive the queen; once she is in the hive, the others will follow within an hour, and the hive can be moved to its ultimate location in the evening.

The parent colony from which the swarm originated needs a thorough inspection for swarm cells, which should all be destroyed when the swarm is reunited with the colony. When no reuniting is desired, all but one swarm cell must be destroyed to allow the colony to requeen by itself while preventing after-swarms. Reuniting may be accomplished with the newspaper method, placing the swarm on top of the parent colony. If the swarm is to be kept separate, it should be supplied with some food and left to settle in for several days. Then, check for disease and brood pattern, and give extra space when required. Swarms are

generally made up, in part, of many young bees that will quickly draw out foundation and produce honey.

A swarm in late May or June will grow to fill two brood chambers and will winter successfully. Swarms in July and August will have less opportunity to grow in population before the summer ends. Such swarms may perish if wintered outdoors, but may survive if wintered indoors. Alternately, late swarms may be united with weaker colonies to boost their populations.

Removing Honey From the Hive

The beekeeper must always remember that honey is a food. Great care must be taken to ensure the honey is kept as pure and clean as possible. Make sure no medications are given to the bees during the time of honey flows.

When to Remove Honey

The number of times honey is removed from honey bee colonies depends on the beekeeper's preference and the size of the operation. A hobby beekeeper may wish to super the colonies and then leave them until the main nectar flow has finished before removing and extracting the honey.

The commercial beekeeper who wishes to maximize honey production will remove honey supers from the colonies two and often three times through the nectar flow, replacing them with empty supers until the flow finishes. Colonies do tend to slow down honey production somewhat as honey stores increase. If the honey stores are removed regularly, the colonies will probably continue to operate at a high pitch, and overall yields are likely to be higher.

The timing of the first honey extraction depends, to some extent, on the beekeeper's preference and the number of colonies operated, as well as on such factors as the weather and the intensity of the flow. The beekeeper generally keeps a close watch on the colonies to know when supers are filling up at each site. The beekeeper should then begin removing honey accordingly, commencing with the more advanced yards and working around to the slower yards. It is time to remove a super if a good portion of the comb space is filled with honey. If the honey is capped across the upper third of the frame, the honey will be adequately cured. In some areas, and especially at the end of a honey flow, uncapped combs may be ready for harvesting anyway.

Honey supers in which the honey is completely capped indicate a potential loss of honey production. Under dry prairie conditions, capped honey may contain as little as 13-14 per cent moisture, while the maximum moisture content allowed in Canada No. 1 unpasteurized honey is 17.8 per cent. Frames that are partially capped contain both low moisture honey and high moisture honey, averaging out to an acceptable percentage. In addition, low moisture honey is thicker and more difficult to extract. Honey that drips like thin syrup or that shakes out of a frame is unripe and must be left on the hive for further processing by the bees.

Finding the fine line between unripe honey and ripe honey requires good judgment, precise timing and the use of a honey refractometer (to test the moisture content of honey). Uncapped honey is often slightly higher in moisture content than is desirable. As a result,

The beekeeper generally keeps a close watch on the colonies to know when supers are filling up at each site.

the beekeeper must either have some means of bringing the moisture content down in the honey house before extracting or wait for the honey bees to complete the process.

Removing honey from the hives should not be delayed, especially in a cool summer in regions where canola and mustard are grown. Honey from these crops tends to crystallize readily, even in the comb, and this honey is then impossible to extract.

Recently, some prairie beekeepers have been experimenting with taking honey supers off after most of the excess moisture has been evaporated but before capping has begun. Bees store ripened honey more readily in cells that are not too full, and the last bit of cell length takes the longest to fill. Removing supers before cells are completely full may, therefore, increase honey yield, simply by providing more empty space and avoiding slowdowns related to a lack of storage space. Furthermore, the bees consume honey to produce beeswax. Therefore if honey is removed before the frame is capped, then honey that would otherwise be converted into cappings wax is available for harvest. With this method, there is little or no beeswax to be processed.

If the queen has laid eggs in the honey supers, the frames with brood should be removed before the extraction process. These frames may be moved down into the brood chambers or accumulated in extra boxes and given to weak colonies as an extra brood chamber. Usually after the first honey is removed, the nectar flow is on in full force, and the bees tend to form a honey barrier that keeps the queen from moving upwards again for the duration of the flow.

As honey supers are removed, more empty supers are added to the hive. If nectar is still being brought in at the time of the second pull, hives may be supered again. When the honey flows are over, all honey supers are removed, and colonies are left with just the two brood chambers. Occasionally, a late flow will occur in which the bees could produce another super of honey, but most late flows are minor and serve to fill up the brood chambers with stores for the winter or for next year's packages or nucs. Monitor the situation and be prepared to super the bees again if conditions warrant.

Robbing

During inclement weather or when there is no nectar flow, bees will try to steal honey from any frames exposed to them. This practice is called robbing and must be prevented as much as possible. Besides the danger from the possible spread of disease, it is unpleasant to work in a bee yard where robbing is happening. Supers should be covered as they are loaded on the truck – to prevent both robbing and dust contamination.

Removing Bees From the Honey Supers

Before removing the honey supers from the hive, bees must be removed from the honey supers for the beekeeper's ease and comfort and to maintain the bee population in the hives. There are several ways of removing the bees.

Shaking and brushing

Supers to be extracted are taken off the hive, and as each frame is removed from the super, the bees are shaken from the frames in front of the hive with one or two sharp downward movements. It helps to use a second super, with a lid, to receive the beeless frames. A bee brush or any soft brush may be used to brush away stragglers.

Alternatively, each frame may be brushed clean of bees. Shaking and brushing are quite effective in good weather when there is no danger of robbing, and there are few supers to deal with. Bees tend to get quite cross when they are brushed – shaking the frame in front of the hive seems not to anger them as much. Keep a smoker on hand to help calm the bees. Shaking and brushing are useful methods if only a few supers of honey are to be removed.

Bee escape boards

Bee escapes work as one-way gates: bees can go through but cannot return (Figure 29). If an inner cover containing one or more bee escapes is placed between the honey supers to be removed and the rest of the hive, the bees tend to move down to the brood nest, thereby vacating the honey supers. The bee escape boards have to be left on for several hours – usually overnight. Bee escapes work quite well providing there is no brood in the honey supers as bees will not leave brood.

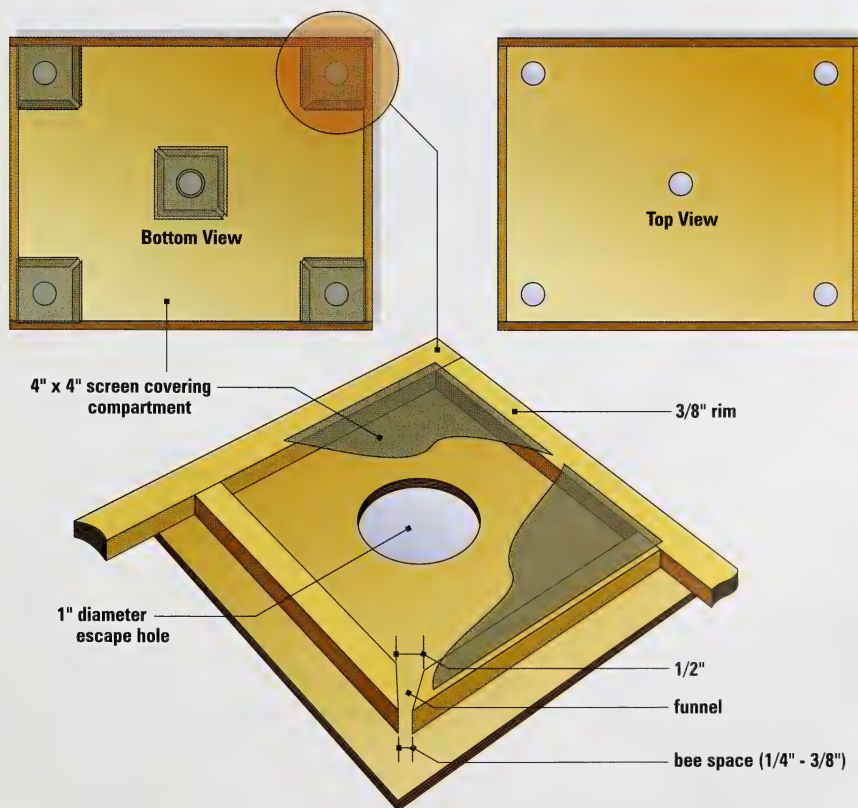


Figure 29. Bee escape board.

Equipment must be bee-tight; otherwise, the supers may be robbed of all the honey before the beekeeper comes back to remove them. Honey supers are best removed in the early morning, before bees are flying, to prevent the bees from finding cracks in the hive and robbing the supers. Bee escape boards may be enhanced by placing them directly above a shallow super containing no frames, thereby giving ample cluster space for the vacating bees. The screened hole in the centre of the bee escape can be two inches in diameter (Figure 29) to further enhance effectiveness. (Commercial, spring-loaded bee escapes are available, but they seem to plug easily.)

Bee escape boards are useful, especially in smaller operations and for hobby beekeepers. However, using them means the beekeeper must make two trips to the bee yard from one to three days apart, and the honey supers must be lifted twice. Empty supers must be available for each hive before full supers are removed and extracted, so some extra honey supers may be required.

Fume or acid boards

Fume boards (Figure 30) are the most common means of taking honey off hives. (The term “acid” refers back to a time when carbolic acid or phenol was the common chemical used. Carbolic acid is no longer legal for use.) Fume boards are made of a wooden frame with two layers of absorbent fabric such as flannelette tacked over one side under a layer of tin that is painted black for heat absorption. Butyric anhydride is sprinkled on the fabric.

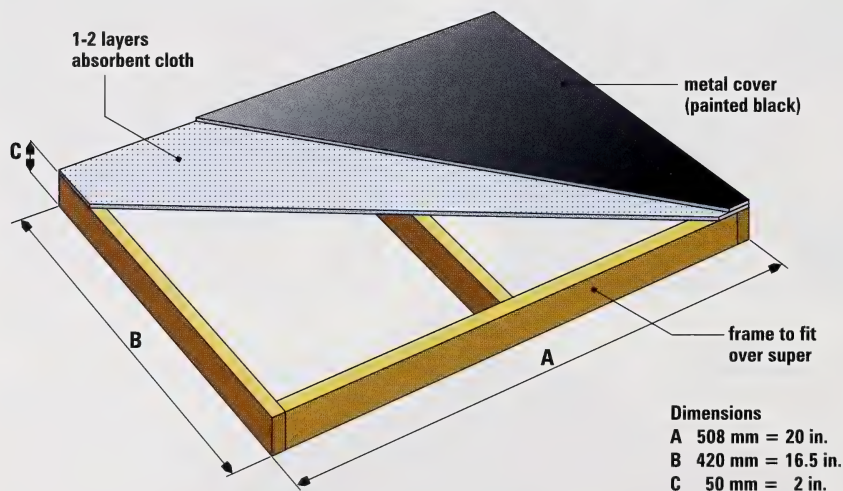


Figure 30. Acid or fume board (cut away view).

The outer cover or lid of the hive is removed, and after the bees are smoked to start them moving down, a fume board is placed on top of each hive. The fumes act as a repellent, driving the bees down. The top super is removed when all the bees have moved out, a few more puffs of smoke are given, and the fume board is placed atop the next super until all honey supers have been cleared of bees and removed.

The major drawback to the use of fume boards is the possibility of honey contamination. Take care to make the rim of the fume board deep enough (5 cm) so that the wax or honey on top of the frames does not come into contact with the chemical on the cloth. All burr comb must be removed before placing the fume board on each super. Also, it is not necessary to soak the flannelette; a few drops of the chemical repellent will do the job and will prevent drips onto the super of honey.

Under hot, sunny conditions, fume boards function quickly to drive the bees from the supers. Consequently, the fume boards should be left on only long enough to drive the bees from the super; at which time, the super is removed, and the fume board is placed on the next box or hive. If fume boards are left on the hives too long, the possibility of honey contamination is greatly increased. Fume boards work more effectively if all the wax bridging across the top of the honey supers is broken. This condition allows the fumes to reach all the bees.

Stacking the fume boards, cloth side to cloth side and tin to tin, immediately after finishing in each yard will help retain the chemical effectiveness for the next yard.

Butyric anhydride (Bee-go, Honey-Robber)

Butyric anhydride is very effective as a bee repellent and the only product currently registered for this use. This chemical has a very disagreeable odour. If too much chemical is used, the bees will become stupified and will not move down out of the super. If this situation happens, remove the super and place it on the ground so the frames are vertical. The stupified bees will then leave the super on their own.

Carbolic acid and benzaldehyde

At one time, both these chemicals were used with fume boards, but neither are currently registered as bee repellents and **should not be used**. The use of either of these products may leave residues that could prevent the honey from being sold.

Bee blowers

Bee blowers use forced air to remove bees from the honey supers. Many commercial beekeepers use blowers as a back-up system on cold, cloudy days. These blowers are especially useful when queen excluders are on the hives, as excluders inhibit the downward movement caused by fume boards. Blowers can also come in handy in the fall to reduce colonies to two brood chambers for wintering or to blow dead bees out of equipment after killing colonies.

Honey supers are removed from the hive and placed on a stand in front of the hive. The blower is used to direct a stream of air between each of the frames, and the bees are blown out of the super in front of the hive.

Blowers are available in both backpack and free-standing models with stands and chutes of various descriptions to direct bees to their hive entrances. These tools are a fast, efficient, though noisy, means of removing bees from supers, and the bees do not seem to become angry or aggressive. There is a possibility of queen loss if she is blown from the honey supers and does not find her way back to the hive.

Abandonment

The abandonment system works well at times when the bees are experiencing a good honey flow. In this system, the full honey supers are removed and placed on the ground (on pallets) or on top of hives with the frames in a vertical direction. The hives can be immediately supered up again. During the next few hours, the bees will leave the original honey supers and return to their hive to continue work. Many beekeepers find it effective to leave the honey supers out overnight, picking them up in the early morning (Figure 31).



Figure 31. Supers on hives.

The bees will not abandon any patches of brood, so queen excluders must be used with this system. With this system, two trips must be made to the apiary to harvest the honey, and the heavy honey supers must be handled an extra time. The abandonment system cannot be used when there is no honey flow as it will promote robbing.

Loading and Movement of Honey Supers

While the “arm-strong” method of moving heavy honey supers within the bee yard and honey house may be sufficient for a small number of hives, heavy lifting is one of the chief drawbacks of beekeeping. Beekeepers can minimize this problem by using various devices.

Good quality, single-stack pallets greatly simplify the movement of honey supers and act as trays to catch any dripping honey (Figure 32). Supers are placed on pallets on the truck and further movement on the truck and in the honey house is accomplished with a two-wheeled super cart (Figure 33). Thus, the supers are moved in units of five or six rather than one at a time. Tailgate loaders are available on which supers may be stacked on pallets, then lifted mechanically and wheeled into place on the flatbed with the cart. Alternatively, boom hive loaders may be used to facilitate the movement of honey supers as well as honey bee colonies (Figure 34).



Figure 33. Super cart.

Figure 32. Honey super pallet.

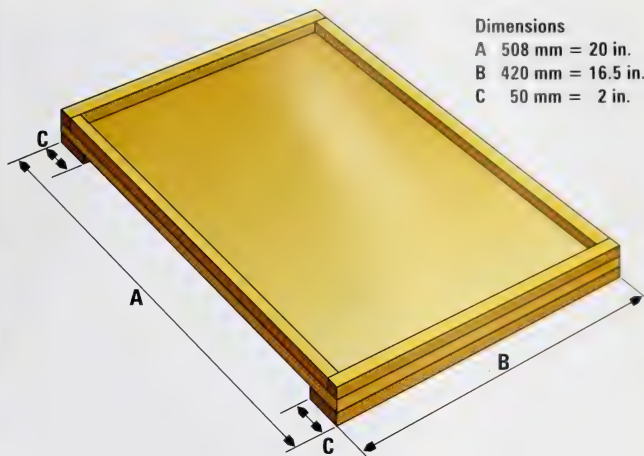


Figure 34. Boom loader.

Some commercial beekeepers with many colonies have converted to a palletized forklift system. Large pallets that can hold four or six stacks of supers are used. The honey supers are stacked on the pallet while it is on the ground, and the forklift lifts the pallet onto the truck. With this system, a forklift or pallet jack is also needed in the honey house. The supers are now moved in units of 20 to 30 or more.

Honey

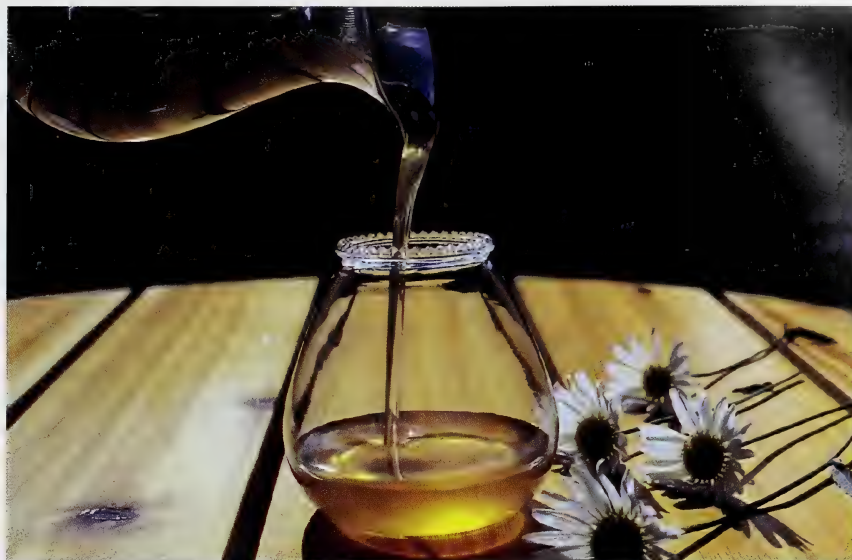


Figure 35. Honey is a sweet liquid.

Honey is a sweet, viscous liquid that bees produce from nectar (Figure 35). Once stored and capped in beeswax combs, honey remains stable and can be used as food by the bees over many months. If handled properly by the beekeeper, honey retains its quality, but remember honey is a potentially perishable food product. If attention is not given to careful handling from comb to container, honey can easily lose its unique and delightful fragrance and flavor, and it can even spoil.

Composition

Honey is composed primarily of the invert sugars levulose and dextrose (fructose and glucose), with small amounts of sucrose, maltose and other sugars, minerals, proteins (mainly enzymes), pigments, acids and essential oils that add fragrance and flavor. The Canadian Food and Drug Act defines honey as containing no more than 20 per cent water, 5 per cent sucrose and 0.6 per cent ash (minerals), and no less than 65 per cent invert sugars. The Canadian Honey Regulations use a similar definition. In both cases, alfalfa honey may not have more than 10 per cent sucrose. Fragrance, flavor and color vary according to the plant species. Honey ranges from white and mild-flavored to dark and strong-flavored.

Viscosity

Honey is viscous. That is, it does not flow freely, and this characteristic affects honey movement through the extracting system. Viscosity also affects the rate at which air bubbles and suspended particles, such as wax, float to the surface. Thick honey has a high viscosity or good body; thin honey has low viscosity.

Both the temperature and moisture content of the honey affect its rate of flow.

Both the temperature and moisture content of the honey affect its rate of flow, with warm temperatures and/or high moisture content causing a decrease in viscosity. That is why beekeepers put honey supers in the hot room for a day before extracting and why they heat the sump and settling tanks. There is a rapid decrease in viscosity up to 30.3°C (86.5°F) for honey with a 17.5 per cent moisture content, and very little is gained by keeping honey at temperatures higher than that. For lower moisture honeys, a temperature increase of 3.6°C (6.5°F) is needed for each percentage decrease in moisture to obtain the same viscosity, so a low moisture honey may require a dangerously high temperature for extraction.

Moisture Content and Hygroscopicity

The moisture content of honey affects its viscosity, weight, handling, grading, rate of granulation and tendency towards fermentation. Moisture content can easily be determined with a honey refractometer, available at bee supply houses. The specific gravity of honey (its weight in relation to that of water) is higher than water and varies with the moisture content: the higher the moisture content, the lower the specific gravity. Consequently, a given volume of 14 per cent moisture honey weighs more than the same volume of 18 per cent moisture honey.

Honey is hygroscopic, which means it will absorb water from the atmosphere until an equilibrium point is reached. For 17.4 per cent moisture honey, this equilibrium is reached at 58 per cent relative humidity (R.H.), and moisture will neither be gained nor lost at this R.H. Other honeys held at 58 per cent R.H. will gain or lose until they reach 17.4 per cent moisture. A low R.H. will cause the honey to lose moisture. Thus, when honey supers are stored in the hot room, there is a chance of moisture loss unless the relative humidity is maintained at 58 per cent. This principle is used in reducing the moisture content of high-moisture honey before extracting by blowing warm, dry air over the surface of the honey combs. A wet and dry bulb thermometer may be installed in the hot room for keeping track of relative humidity, while a refractometer may be used to monitor honey moisture content.

Honey stored above 60 per cent R.H. will absorb water from the atmosphere, initially into the surface layers and gradually throughout the honey. This process may be used to raise the moisture level of honey, making it easier to extract. However, take care that the moisture content does not rise to unsafe levels and cause spoilage through fermentation.

Fermentation may also occur if high-moisture honey is extracted and stored rather than treated to bring the moisture content down before extracting. Once honey is extracted, its moisture content is very difficult to lower, except by thorough blending with a low moisture honey, a process beyond the scope of most commercial beekeepers.

Granulation

Honey is a supersaturated solution of dextrose in the presence of levulose, and in time, the excess dextrose generally precipitates and forms crystals. Granulated honey, then, consists of crystals of dextrose surrounded by a solution of levulose and water. The tendency of a honey to granulate depends on the relative proportions of dextrose and water.

Honeys with a high dextrose content, such as canola and dandelion honeys, will granulate very quickly, while honeys with more levulose, such as fireweed, may granulate very slowly or not at all. Most Canadian honeys will granulate naturally.

Temperatures fluctuating between 5°C and 7°C (41°F and 45°F) appear optimum for the initiation of granulation, while temperatures around 14°C (10°C-18°C) [57°F (50°F-64°F)] are ideal for granulation to proceed rapidly. Honey that granulates quickly is smoother and has a finer texture than slowly granulating honey. Granulation does not occur above 27°C (81°F) and below freezing. Granulation occurs very slowly below 10°C (50°F).

High moisture honey will result in a creamier, softer granulation, and low moisture honey crystallizes more coarsely. Placing honey storage tanks in a heated location or using water-jacketed tanks for settling will help keep granulation from occurring before the honey is packed.

Maintain Honey Quality

To be of high quality, extracted honey should be as similar to honey in the comb as possible. Improper handling may incorporate wax particles and air bubbles into the honey, which will give it a cloudy appearance. Dust, dead bees and other foreign objects in the finished product show a lack of adequate care and sanitation. Honey is most easily damaged through high moisture content and high temperatures when handling and storing.

Fermentation

Few organisms can tolerate honey's high sugar content, but there are several sugar-tolerant yeasts that occur naturally in honey. At moisture levels below 17.1 per cent, these yeast species survive in a dormant form (spore) and cannot reproduce. However, when the moisture content is over about 18 per cent, the yeast cells can begin to grow and multiply, feeding on the sugars and changing them to alcohol and carbon dioxide. This action results in honey spoilage or fermentation. The alcohol may break down to acetic acid (vinegar) and water, giving the honey a distinctly sour and "off" taste, a funny texture with small bubbles and a heaving or foaming surface due to the presence of carbon dioxide. Extensive fermentation will cause containers to burst their lids and overflow.

Honey from 17.1 per cent to 18 per cent moisture will be relatively safe from fermentation; however, between 18.1 per cent and 19 per cent moisture, fermentation within a year is likely. If the moisture content is over 19 per cent fermentation will undoubtedly occur within a year.

In addition to moisture content and yeast count, the extent of granulation and the storage temperature will affect honey’s tendency to ferment. Once dextrose has crystallized, the resulting solution of levulose and water may be higher in moisture content than is safe for honey storage, and fermentation may occur in the liquid portion.

Storage temperatures under 10°C (50°F) are desirable because granulation occurs slowly, and yeasts do not grow or reproduce at all at these temperatures. Freezing is ideal for small amounts of honey, as neither granulation nor fermentation will occur while in storage. By contrast, fermentation will not occur at temperatures above 27°C (81°F), but long-term storage at such high temperatures will damage the honey.

The pasteurization process serves to both kill the vegetative form of the yeasts and to dissolve dextrose crystals and retard granulation (Table 5). At high temperatures, the time periods are extremely short, and a system of flash heating and immediate cooling must be used to avoid heat damage to the honey. Honey that has begun to ferment can be heated to 66°C (150°F) for a short time (less than three minutes); this heat treatment will stop further fermentation and may drive off the sour taste.

Table 5. Yeast destroying temperatures and minimum time	
Temperature	Time
52°C	470 min
54°C	170 min
57°C	60 min
60°C	22 min
63°C	7.5 min
66°C	2.8 min
68°C	1.0 min

Taken from Townsend. G.F. *Preparation of honey for market*. Ontario Ministry of Agriculture and Food. Agdex 616. 29 pp.

Heating and Storage

Heat is used in the honey house and packing plant for several reasons: to reduce viscosity, kill yeasts, dissolve crystals and make processing easier. If too much heat is applied to honey during handling, the honey quality will suffer through changes in fragrance, flavor and color. These same changes will occur if honey is stored at temperatures above 10°C. The higher the storage temperature, the shorter the time before quality begins to deteriorate.

Tests have been developed to measure the level of a chemical breakdown product, hydroxymethylfurfural (HMF), in honey samples as an index of deterioration through overheating or poor storage conditions. Levels of honey enzymes such as diastase and invertase can also be monitored, as enzymes are generally sensitive to heat. These factors are important, especially to the beekeeper who wishes to sell honey overseas, as some countries will require certain HMF and diastase levels as indicators of proper processing.

Honey to be graded and classed under the federal regulations must meet certain HMF and diatase levels.

Food thermometers can be used to check honey temperature as it runs through the extracting system, paying particular attention to temperatures in sump tanks and heat exchangers.

Extracting the Honey

Whether designing a new facility or altering an old one, the beekeeper should first visit other beekeepers and discuss the advantages and disadvantages of their honey houses, extracting systems and storage facilities. The beekeeper should also remember that while the honey house must be adequate, it need not be luxurious. If money is not available to manage the beekeeping operation, then the honey house will be of little value. However, realize that the honey house is used to process a food product, so it **must** be of a suitable standard.

Honey House Considerations

Honey house types

Most modern honey houses are single-storey with relatively simple construction: concrete floors, high ceilings and large doors. Two-storey honey houses allow the use of gravity flow for some of the extracting process. However, unless this latter type of honey house is built into a hill to allow off-loading on both floors, moving equipment from one floor to another will be awkward and time-consuming. Having good quality honey pumps overcomes the disadvantages of single-level honey houses. In addition, one-storey buildings are more easily expanded, altered and adapted to other types of industry.


An old building such as a school can often be altered to make a very good honey house. Floors and foundations may need to be strengthened to take the weight of honey supers and barrels. For the beekeeper with a smaller operation, a garage or small shed will be quite adequate.

Location

Take considerable care when deciding on the location for a new honey house. The resale value of the facility must be considered. If the honey house is built away from the beekeeper's residence, it can be sold in the future and the residence retained. Also, potential exposure of the beekeeper's family to occasional stings can then be reduced, which is especially important if family members have had allergic reactions to bee stings.

When building in rural areas, consider a number of factors:

- availability of water and power
- sewage disposal
- site drainage and elevation
- accessibility for large, heavy trucks
- availability of natural gas (possibly)



Take considerable care when deciding on the location for a new honey house.

Plan for future development before constructing even the first building on a site. Many municipalities have restrictions and rules for site developments, and these must be followed. Be aware that large developments in remote areas may have a very poor resale potential.

A honey house located on the outskirts of a town is convenient with respect to the availability of services and adequacy of roads as well as being close to a potential labor supply. However, caution is advised in locating too close to residential areas as future zoning bylaws may cause problems.

Insurance

Insurance is, of course, highly desirable for sideline or commercial beekeeping operations. Premiums will depend on the location and design of the honey house and storage facilities. If the operation is located in or near a town with a fire department, premiums will be lower. Also, locating wax-rendering facilities and storage areas in separate buildings will reduce insurance premiums.

Space

Whether the honey house is a specially constructed building, a converted schoolhouse or a two-car garage, there are several considerations to make in planning its layout.

A major consideration with the honey house is to make sure there is ample space for moving honey and equipment easily and efficiently. It is very important to have an efficient flow-through design from unloading to reloading the honey supers and from uncapping the frames to packing the honey (Figure 36). The layout should be planned carefully to avoid bottlenecks (Figure 37).

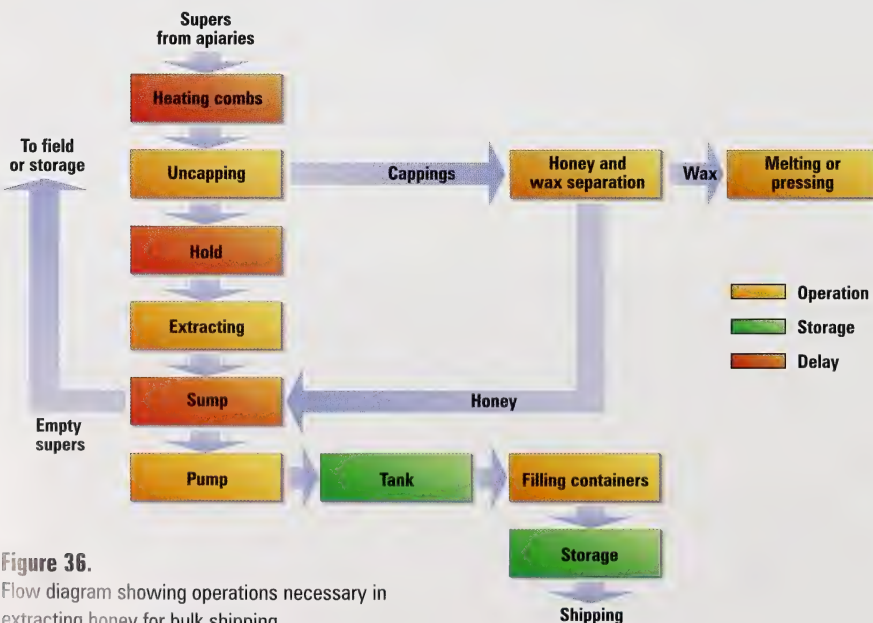


Figure 36.
Flow diagram showing operations necessary in extracting honey for bulk shipping.

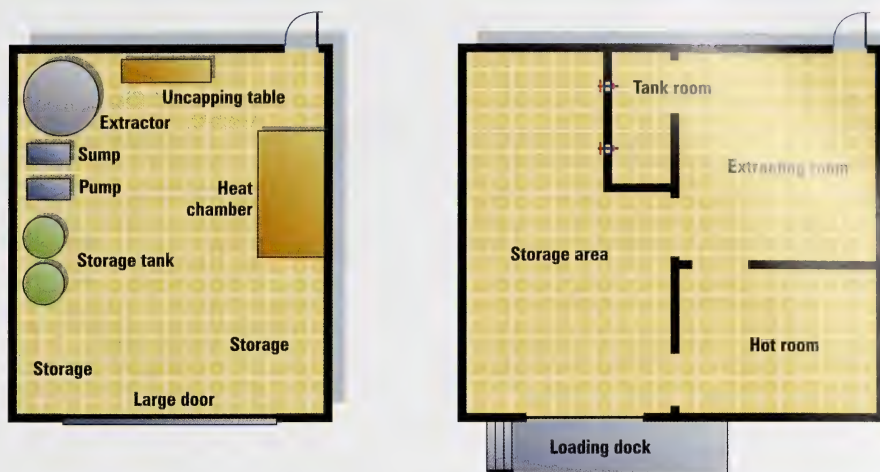


Figure 37. Honey house layouts.

The use of sliding or overhead doors further conserves available space compared to using swinging doors. Sliding doors are recommended in heavy traffic areas, such as entrances to storage areas, the hot room and the extracting room. Hanging plastic strip doors work well to keep heat in one room but still allow easy passage from one area to another.

Space is also needed for the storage of honey supers before and after extracting, storage for honey containers and winter storage of hive equipment.

Allowance for expansion must be taken into account. Should the beekeeper plan to palletize the beekeeping operation, the honey house must be able to accommodate the future use of forklifts. As farm honey sales increase, a salesroom may become desirable. Workshop space will be required, and a staffroom and wax-rendering area may be considered. Wax-rendering and boiler rooms should be located in another building, if possible, to reduce the danger of fire in the honey house.

Cleanliness

A factor that shares equal importance with space is cleanliness. It is in the beekeeper's best interests to maintain high standards of cleanliness to ensure a high quality product. The honey house and its surroundings must meet certain sanitation criteria to obtain a producer-grader certificate from Agriculture and Agri-Food Canada (see Chapter 9 on Marketing the Crop). Many of the points in this section are covered in the Federal Honey Regulations.

The honey house should not be located close to livestock and stagnant water. A gravelled or paved yard will do much towards keeping vehicles, loading docks and floors clean and free of mud and dust. The honey house and storage areas must be bee-tight; windows should be screened and provided with bee escapes. Doors should be spring-loaded, so they cannot be left open by accident. Plenty of light, both natural and artificial, in the extracting

area will help make a safe, pleasant place to work. Windows may also provide ventilation, and fans can be installed to both increase ventilation and reduce humidity.

Walls should be painted a light color and should be both clean and washable. Floors should ideally be of concrete and be smooth, painted or treated for protection against the acid action of honey and water. Grated floor drain gutters help greatly in keeping the floors clean and non-slippery. Wooden floors are best avoided or at least they should be tiled or coated with varnish. Some beekeepers use stainless steel skirting on the lower metre of the walls for easier cleaning and protection against forklift damage. Washroom facilities must be available for people working in the honey house.

Fermentation and objectionable odours occur when water mixes with the honey and is allowed to stand. This result can be avoided by having drainage water carried well away from the working area, rather than allowing it to stand close to the extracting facility. Honey and wax spills should be cleaned up immediately with a minimum of water. Too much water will simply spread the honey in a thin film, resulting in sticky floors and a fermentation problem. Joints between the floor and walls should be sealed with a silicone sealant or covered to prevent water and honey from seeping under walls and fermenting there.

Regular cleaning sessions during daily operations prevent a build-up of the stickiness sometimes associated with honey houses. Each worker should be provided with a bucket of clear water and a wash rag and be made responsible for the cleanliness of his or her area. At certain times of the day, extracting should stop and a few minutes be devoted to cleaning only, for instance, 15 minutes prior to lunch and quitting time. In this way, honey and wax have no chance to accumulate, which can become a formidable cleaning task at the end of the season.

Special attention should be paid to bee specks on walls and around lights. A shop vac is especially useful in removing bees from windows and lights should they gain entry to the honey house. It is imperative that the vacuum cleaner be emptied some distance from the honey house each day; otherwise, the dead bees begin to rot and smell.

Personal health, hygiene and clothing

Because honey is a food product, health, hygiene and clothing are very important concerns. People with contagious diseases should not be working in the extracting plant. Hair nets should be worn by all. Hands must be washed with soap and water before starting work and immediately after using the washroom facilities. Clothing should be chosen carefully so that loose ends cannot get into the honey (or into moving parts of the machinery).

Hazard Analysis Critical Control Point (HACCP)

The HACCP program serves to ensure food safety by anticipating and preventing hazards associated with ingredients and processing, rather than relying on inspection systems and finished-product testing. All food processors are moving to this process. As time goes on, these secondary processors will be requiring that HACCP principles be practiced by the suppliers – in this case, the beekeepers.

It will be important for beekeepers to be able to track and report on all steps involved in the production of their honey, including the type and method of applying any medications. If a problem is found with any honey, a beekeeper must be able to trace batches of honey back



to their source. Careful record keeping will be required to meet these demands and food safety concerns.

Components of the Honey House

Loading area

The area for unloading and loading trucks should be enclosed for protection against poor weather and robbing bees. If forklifts are not used, a raised dock is necessary for level off-loading. There must be adequate space for manoeuvrability with both forklifts and super carts. The loading area, if large enough, may also serve as temporary storage space for equipment or barrels. Both hot room and storage area should have direct access to the loading area.

Hot room

The hot room is where honey is warmed to reduce viscosity and, if necessary, dried to reduce moisture content. The room should be large enough to accommodate three days extracting supply, in case of poor weather or extractor breakdown. An area of about 0.26 m² (three square feet) should be allowed per single stack of supers. The room is kept at temperatures between 26°C and 32°C (80°F-90°F). Fans may be used to circulate the warm air. The room needs two doorways so that honey supers can be moved from truck to hot room and from hot room to extracting room without having to restack or move supers within the hot room.

If a new building is being planned, give serious consideration to providing in-floor heating in the hot room. This system ensures that the honey at the bottom of the stack of honey supers is as warm as the honey at the top. This type of heating requires the use of ceiling fans to create the air flows needed for efficient honey heating.

If honey is high in moisture, it must be dried before extracting. For the best results, an efficient system of air circulation within the supers is needed for drying honey. Dry air is circulated up through the supers, which are staggered or stacked on side-slatted pallets. The moist air is then exhausted at ceiling level. (This type of drying is very labour-intensive or requires expensive floor pallets and is not in common use.) Dehumidifiers may be incorporated into the system, if desired. A large air volume in the room and a high rate of air exchange will speed up the drying process.

An efficient system will allow about a 1 per cent moisture loss in 24 hours. As mentioned in Chapter 7, at a relative humidity of 58 per cent, honey at 17.4 per cent moisture will neither gain nor lose moisture. Naturally, then, the lower the relative humidity that can be maintained in the hot room, the better the honey drying process will be.

Alternatively, should the honey be too low in moisture for easy extraction, the relative humidity in the hot room can be increased by sprinkling water on the floor. A humidity gauge in the hot room will help the beekeeper monitor the relative humidity.

A single window will attract stray bees, which may be released through a bee escape or removed by vacuuming. One type of bee escape is a wire mesh cone directed outwards and upwards, with the tip of the cone large enough to allow the passage of one bee (about 5 mm).

If a new building is being planned, give serious consideration to providing in-floor heating in the hot room.

Some beekeepers place a black cardboard triangle in the window and bee escapes in each upper corner, so the bees are attracted to the areas of light and eventually find their way through the bee escape. A small catcher colony with one or two frames of brood may be placed outside the window to attract the stray bees. At intervals, this colony may be taken to a bee yard and the bees used as a nucleus hive or added to another colony.

Extracting room

The extracting room contains the extracting system and equipment for handling wax cappings. As this room is the centre of the honey house operation, it should be a pleasant place to work in, both day and night if necessary. Walls should be painted a light color; there should be adequate lighting and enough windows to allow natural light.

Maintain adequate space around machinery for easy movement and ease of cleaning. Give some thought to designing the equipment layout to avoid too much movement of stacks of supers in the extracting area. Much time and labour can be saved if the supers emptied at the uncapper are very close to the frames when they are removed from the extractor (Figure 37).

From that position, the supers of extracted frames are returned to the bee hives or taken to storage. Larger operations may use conveyors or portable frame accumulators to accomplish this “U” flow concept and, thus, avoid the excessive use of forklift or hand carts in the extracting area.

Tank room and filling room

Locating honey tanks in the hot room or another heated area will facilitate settling and retard honey granulation. If the honey tanks are in the hot room, take care not to keep honey in them too long. Prolonged exposure to heat will darken the honey and reduce its quality.

The filling area should not be in the hot room but may be on the other side of the wall. This area should have easy access to temporary storage and loading areas. If barrels must be weighed, a scale should be recessed in the floor in the filling area. If there is only one filling station, the scale can be placed directly under the honey gate for ease of use.

Storage area

Storage space is needed for honey containers, both empty and full, and for hive equipment.

Empty barrels are often stored outside, but ideally, they should be stored under cover to protect them from dust and rain. It is best for full barrels to be stored under cover, convenient to the loading area, until shipped out.

If stored outside, full barrels must be protected from precipitation by means of a roof or tarpaulin. Water must not sit on the barrel lids, especially if bungs are in the lids, as seepage into the barrel will occur. Plastic barrel liners help protect barrelled honey from picking up moisture.

Over winter, hive equipment is stored in unheated warehouses. Beekeepers should seriously consider storing hive equipment in buildings separate from the honey house as a precaution against total loss in case of fire. Losing honey supers just before the nectar flow would be disastrous, whatever the insurance payments.

Locating honey tanks in the hot room or another heated area will facilitate settling and retard honey granulation.

Floor drains

It is important to maintain a clean extracting plant or honey house. Cleanliness reflects on the wholesomeness of the product, makes the production of a clean product easier and increases worker safety and effectiveness. The honey and wax that end up on the extracting plant floor are easily removed with water under pressure. However, effective floor drains are required for easy clean-up. The installation of grid-covered floor drain trenches, with a suitable trap, greatly improves the clean-up efficiency.

Honey Extraction

The choice of the extracting equipment to be used will depend on the following factors:

- size of the beekeeping operation
- available space
- equipment costs
- extracting rate desired
- availability of personnel
- personal preference of the beekeeper

Whatever the choice, the system components should be matched so that, for instance, the wax separating device is compatible with the method of uncapping, and the uncapper and extractor have similar capacities.

Safety considerations

As in all factories and food-processing plants, certain safety precautions must be taken in the honey house. At the very least, drive belts, pulleys and conveyor chains should be covered, both to prevent their being gummed up with honey and wax and to prevent accidents. Loose clothing should be avoided, and rings should be removed when operating extracting equipment. Long hair should be arranged, or netted, so there is no danger of it getting caught in conveyors or belts.

Honey and water are efficient conductors of electricity, and electrical shocks can occur if the wiring has not been installed properly. Electrical switches should be enclosed in waterproof boots, and electrical conduit should be waterproof, with waterproof fittings where it enters motors and switches. Conductors should enter switches and motors from the bottom, so there is no possibility of water leaking into equipment when it is washed down. Electrical motors should be of the enclosed type to prevent the danger of shock when they are washed. Safety codes should be followed in all wiring procedures.

The forklifts used in palletized beekeeping operations may cause accidents if they are overloaded or driven without care. Forklifts should not be used in the extracting room. The operator and other personnel must always be aware of each other's position. Fumes from gasoline or propane driven forklifts may constitute a health hazard in enclosed areas, so be aware of ventilation concerns.

Pallets

Pallets used for supers with full honey frames should be constructed to catch all dripping honey (Figure 32). This construction reduces spillage and the necessity of continual

cleanup of sticky floors. Pallets allow the simplified movement of stacks of supers with forklift, pallet jack or hand operated two-wheeled super cart.

Uncapping devices

When the honey in the combs is warm and at the desired moisture level, the combs are ready to be extracted. The wax coverings or cappings must be removed from the cells before the honey can be extracted.

There are many different devices on the market for removing these cappings. These devices may be simple fork-like comb scratchers or hand-held knives and planes that are heated by electricity or steam (Figure 38). Combs may also be uncapped with mounted horizontal or vertical jiggle knives, across which each frame is moved by hand.



Figure 38.
Uncapping plane.

Most larger operations use uncapping machines with electric or steam-heated vibrating knives that cut the cappings from each side of the honey frame as it passes between the knives (Figure 39). Some of these uncappers use chain flails or chipper heads to remove the wax cappings. All these machines adjust to accommodate different comb thicknesses and the beekeeper's preference for a deep or shallow cut. The wax cappings with honey are usually gathered below the uncapper for further processing.



Figure 39.
Cowen uncapper.

Super elevators are available to ease the honey frame handling and to help the beekeeper avoid constant bending. A stack of supers is wheeled from the hot room and placed directly on the super elevator, which is located to the side of the uncapping device. As the top supers are removed, the elevator lifts the remaining supers to a convenient height.

Some beekeepers build a platform at the correct height by the uncapper. The honey supers are placed on the platform manually. This method requires more handling of heavy honey supers. For beekeepers with larger operations, there is a device available that operates by air or hydraulics to grasp all the frames in a super at one time. Then, the operator guides the frames to the uncapper. The machine does all the lifting.

Frequently, honey bees place burr comb on the top or bottom bars of the honey frames. This wax should be removed at the time of the uncapping/extracting process. An accumulation of wax on these bars will eventually slow down operations in the field. The wax on the top bar can be easily removed by scraping all the frames while they are still in the super. The wax on the bottom bar can be removed by passing the frame across a stationary blade in front of the uncapper.

Because honey frames are not uniform, uncapping machines frequently miss the wax on cells that are shorter than normal. Many beekeepers find it beneficial to have one person watch for these spots and to scratch the cappings before the frame enters the extractor. Often, if a frame is not completely uncapped, it will break during extraction. The “blow out” of one frame will often break several adjacent combs.

The extracting process works most efficiently if there is some sort of “surge” device to hold freshly uncapped frames while the extractor is finishing the previous load. With hand uncapping, this method may be as simple as having a long rack or a circular tray where the frames are placed as they are uncapped. Uncapping machines are fitted to a tray or rack that holds the uncapped frames. The frames are either pushed along by succeeding frames or are carried along by endless chains. In all cases, these surge devices must have trays under them to collect the honey that drips from the frames.

Extractors

All honey extractors use centrifugal force to remove honey from combs. Tangential extractors (Figure 40) are available that hold from two to sixteen frames but are most common in the two or four frame size. Frames are placed in expanded metal baskets, and honey is extracted from one side of the frames at a time.



Figure 40. Two-frame tangential, hand-driven honey extractor.

Frames must be reversed when the first side is half extracted to avoid frame breakage. Very simple machines require the frames to be removed, turned and replaced by hand. In more sophisticated machines, the whole basket can be rotated. The second side of the frame is then fully extracted after which the frames are once more reversed to complete the extraction of the first side. These extractors are either hand or power driven. The actual extraction time is very short, and these extractors are ideal for the hobby beekeeper with from one to ten colonies.

Radial extractors are available to hold from ten to one hundred or more full-depth honey frames (Figure 41). Frames are loaded like the spokes of a wheel, with bottom bars towards the centre and top bars outwards to take advantage of the slight upward slant of the wax cells. Honey is extracted simultaneously from both sides of each frame.

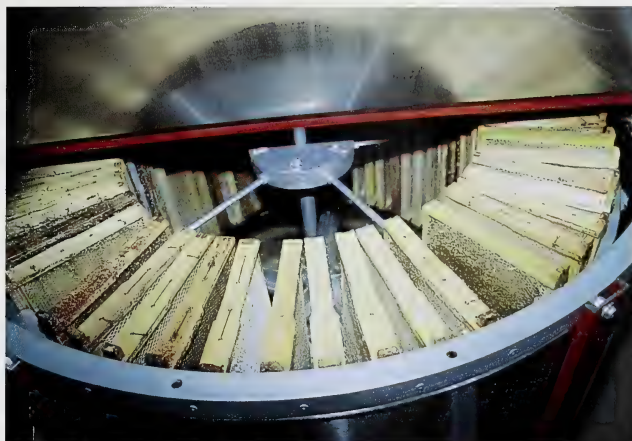


Figure 41.
Vertical axis radial
extractor loaded with
frames.

Extraction time varies depending on the weight of the frame and the viscosity of the honey. To prevent damage to the heavy frames, these machines are run slowly at first and then more quickly as the frames become lighter. Radial extractors may be fitted with a mechanical system of increasing speed, or the speed may be regulated with electrical controls.

Systems are available that incorporate uncapper, surge device, extractor and extractor unloader in one long, integrated device. The frames are moved by chain, in a straight direction, from the uncapper through a holding area into the radial extractor that rotates horizontally. These extractors seem to cause less breakage than vertical extractors, so the extracting cycle can be speeded up. The empty frames are pushed out of the extractor onto holding racks by the full frames entering the extractor. The extracted frames are then placed into empty supers. These systems can be upgraded so that they pick a super of frames from a stack, remove the frames from the super and feed them directly into the uncapper.

These systems extract a lot of honey with a minimum of labour and heavy lifting. One drawback with these long, stretched out systems is that the supers are emptied a long way from where they are filled. The supers can be placed on a conveyor or set of rollers to move them to where they are needed. One very large beekeeping operation installed two systems side-by-side but facing opposite directions so that the empty supers from one machine were used at the other machine. Another drawback to these systems is that they require a very long extracting room.

Many extractors are now made of stainless steel to protect the quality of the honey and to make cleaning easier. Iron and steel will darken honey, especially if moisture and honey are allowed to stay in contact with the metal.

The sump

Extracted honey drains by gravity into a sump or holding tank, located below the level of the extractor. Constructing the sump so that it extends higher than the bottom of the frames in the extractor will prevent an overflow of honey if the pump cannot operate at a critical time. Honey from the cappings often drains into the sump as well. The sump is usually water-jacketed to keep the honey warm, which improves initial separation of wax,

air bubbles and foreign particles. The sump should be covered to keep all foreign material out of the honey. Baffles or coarse screens may be used to further aid settling, as well as to keep foreign objects from running through the pump.

In most cases, honey has to be pumped out of the sump for further processing. The level of the honey in the sump should be controlled by a float that turns the pump on or off. If the pump is turned on and off by hand, mistakes are bound to happen.

The honey pump

Pumps are used if gravity flow is not available to run extracted honey to strainers or settling tanks. Unfortunately, it is very easy to incorporate air into the honey if the pump is not adjusted correctly. Because honey has a high viscosity, the pump should be larger than those used to pump thin liquids. It should only be operated fast enough to keep up a continuous flow of honey, generally at less than 40 per cent of its maximum rating.

Allowing the honey to flow into the pump, rather than the pump having to suck the honey, will keep the pump primed and will reduce air bubbles. The larger the intake and outlet pipes are, the less pressure will be needed to move the honey and, therefore, the less power required. The intake pipe should be larger than the outlet pipe, at least a 5 cm (2") intake and a 3.8 cm (1.5") outlet. Right angles and long lifts in the pipe require more power to keep the honey moving. Make sure all pipes used are rated for use with food. Incorporating a section of clear pipe into the system provides an easy way to monitor the pump visually.

Beekeepers with larger operations frequently use a spin-float system to separate their honey and wax. A very specialized pump is required to pump the honey and all the cappings from the sump. (The spin-float is described under Handling Beeswax Cappings.)


Settling tanks

Tanks vary and may include anything from honey drums with honey gates (specialized taps for thick fluids) in the bottom, to modified milk tanks to custom-made stainless steel or galvanized tanks with baffles.

Commercial beekeepers who sell honey in bulk use settling as their primary means of removing foreign particles and air bubbles from honey. To accomplish this result, tank capacity should be available to allow two or three days settling before running honey into barrels for sale. Several adjoining tanks may be used, each with a one day extracting capacity, or a single adequately baffled tank may be preferred, with the inlet at one end and the outlet at the other. In areas where specialty honey, such as buckwheat, is produced, a beekeeper may have several tanks to keep different colors and qualities separate. The beekeeper may also wish to keep his or her best quality honey separate for retail sales.

Tanks should be water-jacketed or located in a heated room to keep the honey at about 32°C, which reduces viscosity, aids in settling and slows granulation. Covers will prevent the contamination of the honey by airborne dust and dextrose crystals. Stainless steel is the material of choice: galvanized tanks and tanks painted with special paint for food containers are also adequate. Float alarms should be installed to warn against overflow.

Frequent cleaning of tanks should not be necessary: a layer of wax particles on top of the honey helps the filtration of added honey. This wax layer may occasionally be skimmed from the tank, allowed to drain in wire baskets and run through the wax handling system. In



The beekeeper may also wish to keep his or her best quality honey separate for retail sales.

the meantime, tanks should not be drained so low as to reincorporate the wax layer into the honey.

Straining honey

If the beekeeper plans to sell honey directly to consumers and on the retail market, a means of straining the honey may be necessary. Generally, strainers are located between the sump and settling tanks or in the tanks themselves. A baffled and water-jacketed sump removes the coarsest particles and warms the honey: both necessary prerequisites to the movement of honey through a straining mesh.

To meet Canada No. 1 Grade, honey must be “free of any foreign material that would be retained on a U.S. National Bureau of Standards standard 80 mesh screen.” Nylon (45 mesh/cm) and Swiss silk bolting cloth (26 mesh/cm), and Monel metal screen are all satisfactory for straining, provided the honey is kept around 40°C and contains no granulation. Higher honey temperatures will soften wax particles so that they clog up the strainer or pass through, resulting in a cloudy honey.

Bags of straining cloth are submerged in tanks and are supported by stainless steel cages, so straining occurs below the honey surface and over a large surface area. If the straining takes place above the tank, air will be incorporated as the honey falls. Straining bags should be exchanged when they begin to get plugged up.

Packing honey

Once settled and strained, honey is then packed into bulk or retail containers. Each tank is fitted with a honey gate for filling containers. If tanks are joined together, a single honey gate can be used. A scale is located under the gate or nearby for noting barrel weight before and after filling. Barrels should be clean and completely coated with paint recommended for food containers. If not, plastic barrel liners are available to keep the honey from contacting poor-quality barrels.

Honey gates on large tanks can be equipped with shut-off valves in case the gate is knocked off or somehow damaged. Shut-off valves are highly recommended by those beekeepers who have learned about them the hard way.

Retail containers must be new and clean before filling. An accurate scale will be necessary to ensure a correct net weight. Containers should be attractively labelled with the word “honey,” the beekeeper’s name and address, the net weight of the honey, and the honey grade where required by provincial or federal regulations (see Appendix D).

Handling Beeswax Cappings

A large percentage of the weight of wax cappings is made up of honey, so this mixture must be handled carefully to separate honey and wax while damaging neither. Several methods that do not require extra heat are used for separation:

Draining

Beekeepers with small operations can uncapped directly into a drain tub of some sort, for example, a screened super with a slanted galvanized metal tray attached to the bottom with a drain at one end or a screened washtub. Cappings are allowed to drain for 24 hours or

more in a warm room. The honey is then drained into the sump or strainer and processed as usual. Cappings can then be stored temporarily or melted down immediately (see Rendering Beeswax Cappings further on in this chapter).

Feeding cappings back to bees

Taking the cappings back to the bee yard and allowing the bees to clean them up is not generally recommended because of the danger of inciting robbing and the potential for spreading American foulbrood disease. If the cappings are from frames from disease-free colonies, they may be spread on inner covers or placed in special bee-tight boxes atop several hives in isolated yards. Oxytetracycline may be fed to these colonies at the same time, as a precautionary measure, if the whole operation occurs after the nectar flow has ceased.

Centrifugal separation

The beekeeper may uncapped directly into a cappings spinner or whirl-dry, which separates much of the honey by centrifugal force. Cappings may also be augered or pumped into the spinner. The spinner may be a modified extractor with wire baskets to retain the cappings. Once sufficient honey has been removed, the cappings are dug out of the spinner for further processing.

Wax press

Cappings may be pressed to remove much of the honey before further processing. Frames may be uncapped directly into the press, the cappings then pressed into a solid cake and the honey drained off.

The above four methods may leave a fair amount of honey in the cappings, which can then be removed during the subsequent melting process. The following methods call for heat to be applied to the cappings mixture; however, too much heat will certainly discolor honey and may damage the wax as well. Always take special care to check and adjust temperatures.

Cappings melter

The cappings melter, at its simplest, separates wax and honey through warming, melts the wax and drains wax and honey off through spigots at different levels.

One type of melter has a heat source in the bottom to initiate separation and a source of overhead radiant heat to melt the wax. The honey is protected from overheating by the molten wax layer. If the melter is properly constructed and used, honey may be run directly into the sump. Regular checks of the melter must be made to ensure it is correctly adjusted. The color of the cappings honey must also be checked, as it only takes a very small amount of discolored honey to darken an entire tank of honey. Honey darkened in the melter should be kept separate from the bulk of the crop.

Wax is run into plastic wash tubs or other containers with tapered sides and allowed to harden into blocks, then removed and stored. An advantage of the cappings melter is that the honey and wax are separated and the wax melted all in one step. All other methods require initial separation and then subsequent melting of the wax.

Copper, iron, monel metal, zinc and brass will discolor melted wax and should never be used in melter construction. Stainless steel is the material of choice; nickel and tin also



appear to be safe construction materials. Steam heat should not be used in the cappings melter because it is too hot for both honey and wax. Hot water coils in the bottom of the melter are the safest means of heating the mixture. However in the past, a high proportion of the beeswax produced in Canada was processed in galvanized Brand melters with copper steam-heated grids to do the melting.

Spin-float separator

The spin-float separator is an effective means of separating honey from wax and of drying the cappings. The honey and wax from both the uncapper and extractor are continuously pumped through a heat exchanger to warm the mixture. The honey passes from the heat exchanger to the spin float, which uses centrifugal force to separate the wax from the honey. The heavy honey accumulates on the outside of a spinning drum with the lighter wax floating to the centre. The honey moves to the settling tank, and the wax is chipped off the drum and falls to the ground. Cappings from the separator are dry enough to be shovelled. This system works especially well with the types of uncapper that break cappings into small pieces rather than slicing them off the combs. The temperature of the mixture should be monitored to prevent damage to the honey through overheating.

Rendering Beeswax Cappings

Cappings wax is clean, light in color and of a higher quality than wax obtained from broken frames, old brood combs and scrapings. Because of its higher quality, cappings wax should be kept separate from the others for rendering.

If cappings are not processed in a cappings melter, they may be melted in water, in a steam chest or in a solar wax melter. Whichever method is used, cappings containing honey should never be stored for any length of time in containers such as pails or drums. The honey will eventually crystallize, and the mixture will then be very difficult to remove from the containers. Sacks or plastic bags will be easier to manipulate.

Processing cappings in water

For the beekeeper with only a few kilograms of wax, it is feasible to melt the wax in an old pot on the stove. The pot is filled about one quarter full of water. As the water heats, the cappings melt and any honey and particulate matter dissolve in the water, sink to the bottom or float between the water and the layer of wax. The pot is then left overnight. The wax hardens and is removed from the pot in a block. At this point, the bottom of the wax block will require some scraping to remove the layer of impurities.

Alternatively, most of the melted wax may be ladled into containers. A melting pot with a spout near the rim can be used to pour the wax into molds. Once the wax is melted, boiling water may be added to bring the wax level up to the spout, thus decanting the wax into containers. Wax should never be melted over an open flame or on a stove without using water, as there is an extreme danger of fire.

The steam chest

Cappings may be melted in a chest by using the steam from boiling water. If steam is used, then the honey in the cappings cannot be salvaged as honey. Live steam may cause some chemical alteration of the wax and should be avoided.

The solar wax melter

A solar wax melter (Figure 42) is a glass-covered box, sloped in the direction of the sun and painted black inside and out for greater heat absorption. It can be used during the summer months to melt cappings, burr comb, scrapings and old combs, as well as to clean the wax off queen excluders.

Figure 42. Solar wax melter (after Jaycox, University of Illinois).



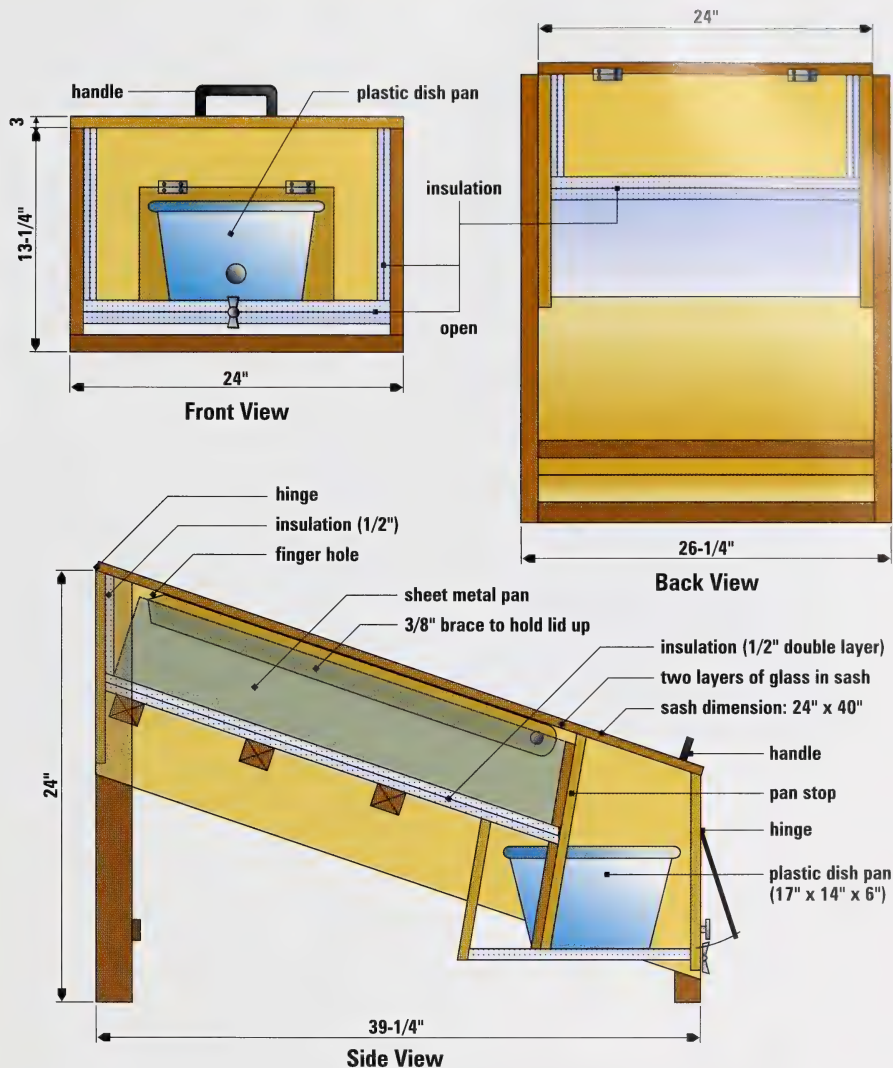


Figure 42A.

Solar wax melter (after Jaycox, University of Illinois).

The hinged glass lid retains heat more efficiently if made with two panes of glass separated by one or two centimeters. Weather-stripping between the lid and the box will help retain heat as well as keeping the melter bee-tight. Insulating the sides and bottom will also help heat retention. A sloping tray of galvanized metal, aluminum or stainless steel, holds the wax while the melting occurs. A removable basket of galvanized mesh or expanded metal may be used over the metal tray to facilitate the removal of residues.

The tray should be 10-15 cm deep and at least large enough to hold queen excluders. Wax and honey run down the tray and through a coarse screen into a container, such as a plastic dish pan, placed under the tray edge. The screen prevents slumgum (the residue left when all wax and honey is melted out of old combs) and unmelted wax from falling into the plastic pan. A layer of darkened honey forms under the wax, and this honey may be saved for spring feed if it is from disease-free colonies. Slumgum will accumulate in the basket, especially when old combs are melted. If enough slumgum is collected, it may be further rendered using a wax press or steam chest.

Rendering Brood Combs

It is difficult to recover the wax from brood combs because of the large amount of wax adhering to old cocoon material, propolis and pollen residues. Wax presses or steam chests are generally used to extract wax from both brood combs and slumgum.

Beekeepers with smaller operations may wish to recover as much wax as possible using a solar wax melter and then place the remaining slumgum and cocoon residue in burlap sacks. If this mixture is soaked for several hours in cold water, the cocoons and other foreign material are thoroughly wetted, and when the mixture is heated, they do not absorb the melted wax. Once heated, the sack is then agitated or squeezed to separate wax from the other matter. When cooled, the wax will harden on top of the water.

Commercial Processing of Beeswax

A number of beekeepers and businesses process cappings and old frames either for a fee or for a share of the wax obtained. Many beekeepers find that using this service streamlines their operation and reduces the equipment investment required.

Marketing the Crop



Figure 43. Honey for sale at a farmers market.

Marketing Honey

Two major markets exist for the commercial beekeeper's honey crops: the Canadian domestic market and the export market. Per capita consumption of honey in Canada is fairly constant at just under a kilogram per year. About one-third of Canada's annual crop is available for export after domestic needs are filled.

The United States, Japan, Germany, France and the United Kingdom are the major customers for Canadian honey exports. Canada also exports honey to other European countries, the Caribbean and the mid- and far-East. Canada produces large quantities of excellent quality white honey that is in demand worldwide, both for consumer sales and for blending with darker honeys to satisfy customer preference for light honeys.

Other leading exporters of honey are China, Mexico, Argentina and Australia. Argentina and China produce lighter honeys and compete more directly with Canada. Mexico and Australia produce darker honeys, so their honeys are not in such strong competition with Canadian honey.

Some beekeepers choose to sell directly to buyers in the United States and overseas, generally working through a broker. As well, some of the honey sold in bulk to Canadian packers is destined for export as either bulk or packed honey. Developing an export market for honey takes time and experience and can involve some risk to the beekeeper or broker.

The beekeeper must know the reputation of the buyer with whom he or she is dealing as well as the honey grading regulations and tariffs of the country in question. Concerns such as who pays the shipping costs and when payment will be made must be included in negotiations. To export honey, beekeepers need to be registered as producer-graders with the Canadian Food Inspection Agency (CFIA).

On the domestic market, the commercial beekeeper can market honey directly to the consumer or in bulk containers to honey packers. Direct sales include sales from the honey house or a roadside stand, farmers markets or to retail outlets (Figure 43).

Because of the large amount of honey produced and the relatively small population in most areas of the Prairies, direct sales account for only a small percentage of prairie honey sales. Beekeepers located near an urban centre may wish to market their honey directly. Before doing so, they should be aware of provincial and federal regulations concerning honey sales by contacting the Provincial Apiculturalist.

Farm gate sales

Farm gate sales take place from the honey house, the beekeeper's residence or a farmers market. Rules for these sales may vary from province to province. Whatever the rules, it is important to provide a well labelled, quality product in a quality container.

Retail store sales

All honey sold on the retail market, i.e. not farm gate sales, must be sold according to the Canadian Honey Regulations. A beekeeper who retails honey must be registered as a producer-grader with the Canadian Food Inspection Agency.

Such registration requires an inspection of the beekeeper's premises and that honey be packed in standard metric-sized containers. The weight of the honey in kilograms or, if under one kilogram, in grams must be marked clearly on the label in both of Canada's official languages. Labels must also be marked with the word "honey," the colour classification and the grade of the honey as specified in the regulations. All labelling must be in both Canada's official languages. The beekeeper's name and address and the producer-grader's registration number must also appear on the container. To avoid problems later, take the time to get a sample label approved by the government before placing an order for a large quantity of labels.

If honey is purchased from other beekeepers and then packed for resale, the beekeeper's establishment must be registered as a packing plant. This certification is also available from the CFIA. Retail honey crossing provincial borders and exported honey comes under federal jurisdiction and must also be packed in a registered establishment.

Direct retail sales, whether within the province or not, require greater care in settling and straining honey than do bulk sales. However, sanitation in and around the honey house should be of a high standard regardless of the honey destination.

The three prairie provinces produce about 75 per cent of Canada's bulk honey. Most commercial beekeepers market their honey in 200 L (45 gallon) drums to honey packers. In the prairie provinces, beekeepers may sell to the Alberta or Manitoba Honey Producers' Co-operatives, or they may sell to private packers across Canada.



From 35-55 per cent of prairie honey is sold to the co-operatives (co-ops), while a similar amount is sold to private packers. Membership in the co-ops must be applied for, and members of the co-ops are expected to be able to ship 2,268 kg (5,000 pounds) of honey annually. The co-ops supply barrels for the honey they will receive. An initial payment is made upon shipment of the honey, with several subsequent interim payments and a final payment being made about 15 months later.

The standard unit of sale for honey on the prairies is a “carload lot” – about 70 drums of honey. Smaller quantities can be sold, but it is sometimes difficult to find a buyer. Terms of private honey sale vary from packer to packer and beekeeper to beekeeper. The cost of transportation and drums must also be taken into account. If drums are exchanged, they may be of unequal quality.

The beekeeper should make every effort to know the reputation of the packer with whom he or she is dealing, and terms of sale should be settled before the honey leaves the honey house. Payment is generally made in full within a certain length of time after the honey is shipped. Payment in full may be more helpful than installment payments for new beekeepers with higher costs. The beekeeper must balance payment arrangements and risk in deciding how to market his or her honey.

Sideline beekeepers may have difficulty marketing their honey, having too much for direct sales and too little for bulk sales. They may wish to sell their honey to a local commercial beekeeper who will then market it along with his or her own product.

The beekeeper should make every effort to know the reputation of the packer with whom he or she is dealing.

Marketing Beeswax

Most of the beeswax produced by the North American beekeeping industry goes to the cosmetics and pharmaceutical industries. Other major markets include the candle-making, industrial and beeswax foundation industries.

Many beekeepers save some or all of their beeswax for trade to beekeeping supply houses for foundation. Beekeepers who wish to market wax to other industries may find it easier to deal through a broker. Industries that buy beeswax usually require relatively small amounts of wax on a steady basis throughout the year, whereas the beekeeper generally wants to market all of his or her beeswax at one time.

Marketing Pollen

Selling pollen to places like the health food markets or manufacturers can be an important source of income for beekeepers. However, take great care to ensure this pollen is pure and clean for human consumption. Pollen that cannot meet such high requirements can be sold for bee feed or animal feed.

Pollen traps must be made of food-grade, easily cleaned materials, and the collections should be made often enough (a minimum of every third or fourth day depending on moisture levels) to avoid the growth of moulds and yeasts. Pollen collected immediately after drug treatments or the adding of supers to hives must be kept separate and used only for animal or bee feed.

Once pollen has been collected, it should be immediately dried or frozen at -10°C (14°F) or colder until further processing. Freezing will help control any insect presence that may be in the pollen.

Raw pollen sales

A number of businesses will purchase raw, frozen pollen from beekeepers for further processing and sale into other markets – both domestic and export. Beekeepers should make sure they have a market before a lot of money and energy are spent collecting pollen. A 200 litre (45 gallon) drum will hold about 135 kg (300 lb) of dried pollen.

Retail sales

Beekeepers can clean and air dry their own pollen and package it for sale at the same farm gate sales where they sell honey. Pollen should be dried to a firm stage to ensure that it will keep. Pollen also must be thoroughly picked through by hand, so no foreign particles get into the package. Further care must be taken to make sure the container has only intact pollen pellets. Large amounts of pollen powder detract from the saleability of the product.

Health food stores

These stores are an obvious place to sell pollen, but it takes time to develop this market. Beekeepers placing pollen into these outlets have to be especially careful to provide a quality product with a long shelf life. The pollen may be in attractive, well-labelled containers or sold in bulk. More importantly perhaps, producers of pollen have to keep their product free of any insect eggs that may hatch and start to feed before the pollen is used. Selling large quantities of pollen into these health food markets may require an investment in very expensive equipment.

Beekeepers

Many beekeepers wish to use pollen as supplementary feeding for their bees in the spring. Pollen sold for this use does not have to meet the strict standards required for human consumption. However, any colonies used to collect pollen for bee feed must be disease-free. Several bee diseases are easily spread in contaminated pollen.

Marketing Other Hive Products

Propolis

There is an increasing interest in the use of propolis as a “natural” antibiotic. From time to time, advertisements appear in the literature offering very attractive prices for propolis. Prices vary, of course, depending on the purity of the product. For example, propolis from hive scraps often has a lot of wood particles in it.

In the past, some beekeepers have had unsatisfactory experiences when selling propolis to distant buyers. The propolis has been shipped, and payment has either been slow, reduced or not come at all. If time is to be spent in collecting propolis, develop and investigate prospective markets ahead of time.

Royal jelly

The production of royal jelly can fit into the management of bee colonies for the production of queen bees. The production of royal jelly is very labour intensive. While royal jelly is



widely available in Canadian retail outlets, there is no defined marketing system. Very careful investigation should be made before embarking on a major royal jelly production plan.

Bee venom

There is a market for dried bee venom, and devices are available for the collection of venom from honey bees. Most venom is used in the pharmaceutical or medical field with very strict requirements for purity and quality. Like propolis and royal jelly, markets must be examined very carefully before the beekeeper invests a lot of time and resources.

Fall and Winter Management

At the end of the main nectar flow, hives are reduced to two or three supers. The beekeeper must now decide whether or not to winter the colonies.

Robbing

At this later time of the year, robbing situations can develop quickly. Colonies have large field forces that are no longer involved in collecting nectar and pollen and that continue to search for food sources. Weaker colonies may be completely robbed unless preventive steps are taken. Any hive manipulations must be done as quickly as possible or when the bees are not flying, and exposure of honey and syrup should be avoided. If certain colonies are being “picked on,” they may be moved or turned, so their entrances are facing in the opposite direction. Place entrance reducers on all colonies.

Since robbing is an efficient means of spreading bee diseases, give antibiotics to each colony, whether it is to be killed or wintered, after the last honey super has been removed.

Package Operations

Colonies should be reduced to one or two boxes at the end of the main nectar flow. This will usually be in mid-August in northern areas and one or two weeks later in the south. It is best to kill the colonies fairly soon after the nectar flow is over, to retain honey and pollen stores in the brood chambers for next year’s colonies. Large commercial operators generally begin to kill colonies right away to get everything finished in short order.

Once killed, bees are generally shaken or blown from the brood chambers in the bee yard. Hive equipment is then loaded onto the truck and returned to the storage area. Sometime between the fall and the following spring, brood chambers must be prepared for the next season’s packages, as outlined in Chapter 5. This sorting may be done at the time of killing or at some time during the winter months if a heated area is available.

Some beekeepers prefer to hatch brood combs before storing their equipment. This approach avoids having capped brood hatch in storage after the colonies are killed. Also, the following year’s bees will not have the task of uncapping and removing dead brood.

Combs containing capped brood are placed in supers and stacked on a few remaining live colonies. After one or two weeks, these colonies are killed after the brood has emerged.

Sometime between the fall and the following spring, brood chambers must be prepared for the next season’s packages.

Note: If there is any history of American foulbrood in the apiary, this procedure is not recommended as it could serve to spread disease. Until they are killed, these colonies should be medicated with antibiotics.

Using Calcium Cyanide to Kill Honey Bee Colonies

Calcium cyanide is presently registered in Canada for use in killing bee colonies. It is marketed in both dust and granular formulations, the dust formulation being used by the beekeeping industry. Calcium cyanide reacts with moisture in the air to release hydrogen cyanide, a clear gas smelling of bitter almond, and it leaves a residue of calcium hydroxide, a harmless dust. Since the closure of the United States border for live honey bees, there has been little demand for this product. Calcium cyanide is currently very difficult to find.

Hydrogen cyanide is *powerfully toxic* to humans as well as to insects as it acts to inhibit the supply of oxygen to body cells. A dosage as low as 200 parts per million will quickly kill a person through inhalation, ingestion or skin contact. For this reason, beekeepers must be extremely careful in handling calcium cyanide. Symptoms of minor exposure are weakness, dizziness, headache, nausea, vomiting, unsteadiness of gait and a feeling of suffocation. Greater exposure will cause fainting, cessation of breathing and death. If exposure has occurred, seek medical attention right away.

Calcium cyanide should be kept in its original container, clearly labelled and stored in a locked or secure place vented to the outside. It should not be carried in truck cabs or left in car trunks for any length of time. Containers should be checked periodically for corrosion or breaks, and empty containers should be crushed and buried.

When using calcium cyanide in the field, don't work alone and try to work upwind of the chemical. Rubber gloves and safety goggles or respirators are recommended. Do not get cyanide dust on your skin or in your eyes. Wash your hands and face between each yard, and change clothes as soon as possible after finishing for the day.

Colonies should be killed during non-flying conditions, such as in cool weather or in the early morning or late evening. Calcium cyanide should be used according to the label directions: 12.5-25 g (1-2 tablespoons) of calcium cyanide are sprinkled on a paper plate or sheet of cardboard and slipped into the hive entrance. Once the chemical is applied, entrances are blocked and the hives kicked or jarred to stir up the bees. The hives are then left for at least 30 minutes, after which the hives are thoroughly aired before removing them from the field. This delay and the ventilation allow the hydrogen cyanide to effect a complete kill and then dissipate before the beekeeper must handle the hive equipment.

Wintering Honey Bee Colonies

The races of honey bees used in Canadian beekeeping are of temperate origin. They are adapted, to a greater or lesser extent, to survive a long, cold winter by forming a cluster and consuming food stored during the summer to generate heat. The technique of wintering colonies of bees in hives simply takes advantage of the colony's natural inclination, and management techniques have been developed that complement the bees' tendencies.

Colonies should be killed during non-flying conditions, such as in cool weather or in the early morning or late evening.

Wintering honey bee colonies is not a new idea. Before package bees were available, wintering was a necessity, and much literature published in the early part of the twentieth century had to do with the refinement of wintering techniques. The advent of the package industry changed Canada's beekeeping industry, and wintering was no longer essential in the prairie provinces. However, over the past couple of decades, there has been an increasingly strong interest in wintering because by importing packages each year, the beekeeper is also importing any problems present in the colonies producing the packages. Diseases such as American foulbrood (AFB), European foulbrood (EFB), nosema and chalkbrood may all be transmitted by adult workers. The possibility of importing other pest problems such as tracheal mites, Africanized bees or varroa mites is also cause for concern.

Beekeepers who have committed themselves to wintering have done so for a number of reasons. Economically, production costs are somewhat lower for wintering operations despite extra sugar, labour and wintering costs. Buying package bees is considerably more expensive than operating wintered hives.

With wintering, beekeepers can make their own stock selection and eliminate stock that does not suit their needs. These beekeepers can then become, to some extent, self-sufficient. The management of wintered colonies is spread over a longer time. If managed correctly, wintered colonies will produce more honey, especially in the early part of the nectar flow. During later flows, for instance in August, package colonies catch up to the productive capacity of wintered colonies.

Outdoor wintering requires special consideration to details and the colonies' requirements. The colonies' most important need is to be fed sugar syrup early in the fall to ensure they have sufficient resources for the winter.

Certain types of honey, such as canola honey, granulate in the combs and do not make good winter stores. Good locations for winter apiaries may be difficult to find, especially in areas where much of the land is treeless. Severe winter kill of colonies is always a possibility, and beekeepers who winter their bees generally count on at least a 10 per cent reduction in colony numbers through starvation, queenlessness and spring dwindling. This figure may be as high as 30 per cent in the first year, as the beekeeper has put package stock into winter that is not necessarily well-adapted to winter survival. High winter mortality is in itself a form of stock selection.

Other concerns involve hive equipment being exposed to the elements year-round; therefore, its life expectancy is reduced. Spring management is more demanding with wintered than with package colonies. Comb sorting and culling must be done during the spring checks instead of after the field work is finished. Most importantly, wintered colonies must be requeened every one or two years, so the beekeeper must develop a method of regular requeening and may find that queen rearing is necessary to obtain the desired stock.

Proper timing is crucial to the success of wintering, whether indoors or outdoors. Colonies must be moved, fed and wrapped or moved inside well before the onset of winter. A beekeeper cannot wait until mid-October to decide to winter his or her colonies because by then, it is too late for the proper preparations, and the chances of success are remote.

What to winter

Only healthy, populous colonies with an abundance of young bees and proven young queens should be prepared for winter. A larger cluster will be more efficient at heat generation and retention and will be able to maintain a larger brood area earlier in the spring than will a small cluster. Most colonies that have built up to high populations through the summer will be strong enough to winter well. Weak colonies and those that have queen problems are not as likely to survive the winter out-of-doors and should be united with other colonies or destroyed. With indoor wintering, there is more leeway; nuclei made up in mid-summer, for example, may be successfully wintered indoors in just one brood chamber. Small, four- to six-frame nucleus colonies are also wintered indoors successfully.

Some experienced beekeepers feel the Carniolan and Caucasian races are better suited for prairie wintering operations than the Italian race, although there is a wide range of variation within each race. Italian strains will winter well but may consume more feed than the darker strains, which winter in smaller clusters and with less food consumption.

Feeding colonies for winter

Feeding colonies at any time is stressful for the bees, and the fall feeding is no exception. Colonies should be managed to minimize this stress as much as possible, to avoid both undue disturbance and disease flare-ups. Keeping this concern in mind, beekeepers have three aims in fall feeding:

- to feed as much as necessary to provide all the winter feed each hive requires
- to feed as quickly as possible to have feeding completed as soon as possible before cold weather arrives
- to feed as thick a syrup as possible to minimize the work required by the colony to store the feed for winter

Inner frame feeders, Boardman feeders and small pails or tins will not hold enough: a 15 kg feeder pail or a hive top feeder is recommended. Suitable feeder types are covered in Chapter 4. Thick (2:1) syrup supplies more food in a given volume than does thin, and it makes less work for the bees as well as for the beekeeper.

The sugar syrup must be inverted, evaporated, stored and capped by the bees before the onset of cold weather, all of which takes time. Once cold weather arrives, colonies take the feed much more slowly, if at all, hence feeding should begin in early September to ensure colonies will have the necessary food stores for winter. Feeding is generally finished by early to mid-October in the north and by late October in the south.

The fall may be an opportune time to control some diseases in the honey bee colony. For example, the most effective time to control nosema disease through feeding fumagillin is in the fall. Refer to the disease control guidelines supplied by your provincial Department of Agriculture for specific recommendations and fall disease control programs.

Hives should contain at least four to six combs of pollen or mixed pollen and honey. Pollen is usually abundant during the summer and is collected and stored around the brood nest. If a pollen shortage should occur, a protein supplement may be fed in early spring to boost brood rearing.



Outdoor Wintering

Colonies to be wintered outdoors must be located in sheltered apiary sites with access to early spring nectar and pollen flows (see Chapter 5, Spring Management). If moving is necessary, do so before fall feeding begins to allow the bees time to recover from the stress of moving, as well as to save the beekeeper's back if colonies are not palletized. Colonies should also be arranged in the desired groupings before feeding and should be off the ground either on cleated bottom boards or on pallets.

Colonies in two brood chambers must weigh between 63 and 73 kg (140 and 160 lb). If in three boxes, the total weight should be from 73 to 82 kg (160 to 180 lb). These weights generally ensure a food supply until the next spring's nectar and pollen flows begin. Reduce the bottom hive entrance before feeding begins to eliminate robbing, and keep the entrances reduced to keep out mice.

Reduce the bottom
hive entrance before
feeding begins to
eliminate robbing,
and keep the
entrances reduced to
keep out mice.

An upper entrance is an important requirement for successful outdoor overwintering. The colony cluster gives off water vapour as it respire, which rises to the top of the hive and must be allowed to escape. Otherwise, this moisture condenses and freezes, forming an ice blockage between the frames. As the cluster moves into the upper super, it will encounter this ice block and starve. By the time the beekeeper begins the first spring checks, the ice will have melted, and the beekeeper will wonder why the bees starved with a box of honey available. The lower entrance may not be used by the bees during winter; it will often be blocked with snow. This entrance should be reduced to a very small size (e.g. 8 mm) or may be blocked off entirely.

An inner cover with a small entrance hole (7-8 cm x 1 cm) cut from the deep side of the rim and a feed hole in the centre can be used both for fall feeding and wintering (see Figure 15). Alternatively, year-round covers may be made from 19 mm (3/4") plywood cut to the dimensions of the super. These covers have 7-8 cm x 1 cm entrances dadoed on one side and feed holes drilled in the centre that are plugged when not in use. The covers are turned over when the upper entrance is not required. The weight of the plywood and propolizing by the bees will keep the cover in place throughout the year. For increased durability, paint both sides and edges, or dip the covers in wax.

Although colonies can live through mild winters without added insulation, insulation will decrease both colony food consumption and mortality. Therefore, insulation is provided to temper the changes in ambient temperature, protect colonies from drafts, help conserve cluster heat and allow more cluster movement within each hive. Insulation also keeps the hive cavity drier.

Hives may be wrapped individually or in groups of two, four or more. Groups of four are the most common and represent the most efficient use of insulation and of heat retention, with two sides of each hive being exposed and two sides being protected. If hives are grouped in larger numbers, those with three protected sides tend to stay too warm, remaining more active through the winter and consuming more food.

Many insulating materials have been used for wintering beehives. Early reports cite leaves, sawdust, shavings and straw while more modern materials include fibreglass, fibrefill and styrofoam. Recently, hives have been arranged in groups of four and wrapped with fibreglass insulation and building paper. R-20 insulation is placed on top of the four-pack, which is then covered with a common plywood lid.

Upper entrances are provided through inverted inner covers and corresponding holes cut through the insulation. A 3" x 5" (75 mm x 125 mm) piece of 3/8" (9 mm) plywood, with coinciding hole, is nailed against the hive to push the insulation snugly in place around the top entrance. The insulation and lid are tied in place with twine, string, wire or tarp hooks (Figure 44).



Figure 44. Hives prepared for winter in insulated "four-pack" arrangement. Hives are wrapped with fibreglass insulation and 6 mil polyethylene and have a common cover. Plywood rectangles coincide with top entrances.

(Photo D. Murrell)

Winter insulation wraps are commercially available or can be made at home. One such wrap is constructed using fibreglass batts totally enclosed in 6 mil black polyethylene. The wrap consists of a single piece and avoids any exposed insulation. It is easy to handle, is relatively mouse-resistant and is easy and economical to construct. The polyethylene protects the insulation from the elements and should greatly prolong the life of the wrap. Commercial beekeepers across western Canada have used the wraps successfully.

R-12 fibreglass, 23" (58 cm) wide batts are placed on a 6-7 foot (2 m) wide sheet of 6 mil black polyethylene. One side of the sheet is folded over the other to cover the batts completely. A medium hot iron is then used over aluminum foil or newspaper to bond the overlapping polyethylene, thus sealing in the fibreglass. The ends are sealed, leaving the corners open to allow air to escape. Templates are made to cut top entrances in the wrap during construction. A similar wrap can be constructed for top insulation using R-20 fibreglass insulation, or one can simply place two pieces of 15 inch R-20 batts inside a standard barrel liner for the top insulation.

Mice and skunks can be a problem in colonies wintered outdoors. Take precautions to prevent mouse damage in hives and insulation and to avoid the decimation of colony populations in fall and spring by skunks, as outlined in Chapter 12.

Indoor Wintering

Colonies to be wintered indoors are fed with sugar syrup before being moved into the wintering building. As is the case for outdoor wintering, colonies should be fed beginning in early September to ensure gross weights of 62-68 kg (140-150 lb) for two-storey hives or 39-45 kg (85-100 lb) for one-storey hives.

Once feeding has finished and the weather has turned cold, the hives are moved into winter storage. On the prairies, this movement typically occurs during late October or early November. Where hives are on pallets, moving them with forklifts may be accomplished quickly and with little disturbance to the bees. If hives are to be handled manually, however, greater time and labour will be required.

Several basic requirements for an indoor wintering facility include the following:

- temperature control
- air circulation
- ventilation
- light exclusion

Before constructing or modifying a building for indoor wintering, beekeepers should visit other indoor wintering facilities and contact their apiculture office for updated information on technology changes.

Ventilation principles of wintering buildings

Honey bee colonies give off heat, water vapour and carbon dioxide (CO₂). The ventilation system removes these by-products by exhausting storage air and replacing it with outdoor air. The temperature, relative humidity and gas composition of the storage air is controlled within a range most comfortable for the bees.

In the late fall and early spring when outdoor temperatures are mild, the heat produced by the bees is greater than the amount required to maintain the storage temperature. This excess heat is removed by exhausting warm storage air and replacing it with cool outdoor air. Exhaust fans controlled by thermostats are used to exhaust this heat. Under these mild conditions, the ventilation provided to control temperature is more than adequate to remove the water vapour and CO₂ produced by the bees. No special provision to control humidity is required.

When the outdoor temperature is very cold, all the heat produced by the bees is required to maintain the inside storage temperature. As a result, the thermostatically-controlled exhaust fans seldom run. However, the bees continue to produce water vapour and CO₂, and unless these by-products are removed, they will continue to build up and will eventually cause problems. A low level of continuous ventilation is therefore used to control water vapour and CO₂.

Figure 45 illustrates the heat and moisture balance for a wintering building under typical winter conditions. Each colony produces approximately 3 to 10 grams of water vapour per hour and 8 to 28 watts of heat. Under normal winter conditions, the heat and moisture production are at the lower end of these ranges.

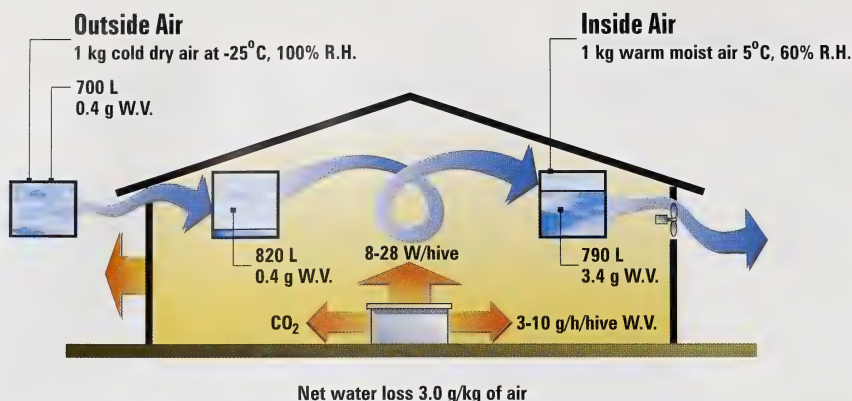


Figure 45. Winter ventilation for overwintering hives

Moisture is removed by replacing storage air with outside air. Even though the relative humidity (R.H.) of cold outdoor air is high when it is introduced into the building, its water holding capacity is increased when it is heated to the storage temperature. For example, 1 kg of outdoor air at -25°C and 100 per cent R.H. contains only 0.4 grams of water vapour. When this same kilogram of air is heated to 5°C , however, at a relative humidity of 60 per cent (a desirable storage humidity), it can hold 3.4 grams of water vapour.

Thus, for each kilogram of storage air exhausted at 5°C and 60 per cent R.H. and replaced with outdoor air at -25°C and 100 per cent R.H., there is a net loss of 3.0 grams of water vapour. Based upon typical conditions, a minimum continuous ventilation rate of 0.25 L/s (litres/second) per hive is required in winter to remove the water vapour produced by the bees.

Continuously exhausting warm storage air and replacing it with cold outdoor air removes a large amount of heat from the storage. To heat the minimum ventilation rate of 0.25 L/s per hive from -25°C to 5°C requires approximately 13 watts of power.

In addition to the heat lost through the ventilation system, heat is also lost by conduction through the building components. This loss is approximately 4 watts per hive at -25°C . Therefore, the total building heat loss is approximately 13 plus 4, or 17 watts per hive. However, the colonies typically produce 10 to 12 watts of heat per hive. The difference between the two heat flows is approximately 5 to 7 watts per hive and must be supplied by a supplementary heating system.

Fan-forced electric heaters are normally used to provide this heat. For design purposes, they should be sized on the basis of 10 watts per hive. This design allows for some factor of safety, since the heat production rate of the bees can vary considerably. The electric heaters are thermostatically controlled to maintain the desired storage temperature.

A problem may occur in late spring prior to removing the bees from storage. Outdoor air temperatures at this time of year can often rise to 15°C or more. Therefore, it becomes difficult to use outdoor air to maintain storage temperatures of 4 to 7°C .

The approach of most beekeepers has been to use high airflow rates, maintaining the storage within a few degrees of the outdoor temperature. Since these periods usually last only a few hours (mid-day), this method has proven relatively successful. It seems the bees can tolerate storage temperatures as high as 15°C for a short period, provided they have a good supply of fresh air. Recirculating a high airflow is also important because it helps remove the heat from the hives.

Design recommendations

1. Building Size

The interior building area normally varies from 0.25 to 0.3 m³ (2.7 to 3.2 ft³) per hive, allowing from 0.7 to 0.9 m³ per hive (24 to 30 ft³ per hive). Loading densities within this range allow plenty of room for air to circulate. Though higher loading densities are physically possible and would reduce building costs, beekeepers who have tried this approach have frequently had more problems wintering. It appears the extra volume of air per hive in a larger room moderates temperature fluctuations and permits better air circulation.

2. Building Construction

Practically any building type or shape can be used for wintering bees. Insulation in the walls and ceiling should be equivalent to RSI 3.5 and RSI 5.0, respectively. The building foundation should be insulated with 50 mm (2 in.) of polystyrene insulation.

3. Ventilation System

The amount of heat and moisture produced by the bees can vary widely. Feeding methods, storage temperature, type of bees and many other management factors all affect the rate of heat and moisture production. Ventilation and heating recommendations (Table 6) are therefore based on “average” conditions and can be expected to provide a good storage environment.

Relative humidities for storage typically range from 50 to 70 per cent. Ventilation rates within the guidelines given in Table 6 will normally result in humidities within this range.

Table 6. Ventilation Recommendations

	Fan Capacity (L/s/hive)	Total Capacity (L/s/hive)
Step 1 (minimum, continuous)	0.25	0.25
Step 2	0.50	0.75
Step 3	1.00	1.75
Step 4	3.25	5.00
Recirculation System		5.00
Intake area (adjustable) – 10 cm ² /hive maximum to 0.5 cm ² /hive minimum		
Heater capacity – 10 watts/hive		

Most wintering buildings on the prairies use a series of exhaust fans in combination with a recirculation fan and a polyethylene duct distribution system (Figure 46). Intake air is admitted through an adjustable opening near the recirculation fan. This air is mixed with recirculated room air and distributed by the polyethylene duct. The recirculation fan and polyethylene duct ensure uniform conditions are maintained throughout the room. The airflow past the hives increases heat transfer from the hives. This cooling effect is especially important after a temporary warm period.

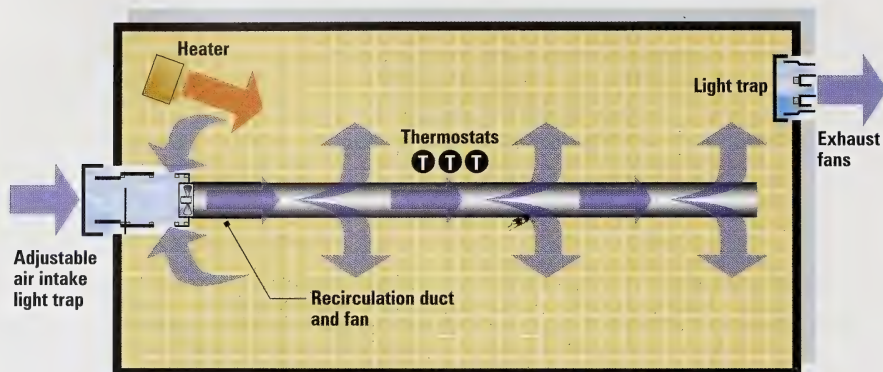


Figure 46. Ventilation system for overwintering hives

Livestock building ventilation fans are readily available and are quite satisfactory for honey bee wintering buildings. A two-speed recirculation fan is often used. It can be operated on low speed during the colder months when a minimum of fresh air is introduced and can be switched to high speed when cooling becomes more critical.

A continually running exhaust fan (Step 1, Table 6) provides moisture control in very cold weather. As the outdoor temperature increases, Steps 2, 3 and 4 are progressively turned on by thermostats as additional cooling is required. The heater thermostat controls the minimum temperature and is set at the lowest desired temperature, normally approximately 4°C.

To ensure the Step 2 fan does not run when the heater is on, the setting between the heater and Step 2 thermostats should be approximately 3°C. The fan thermostats are then set in steps with a difference of approximately 2°C between steps. Mounting the thermostats side by side, preferably in the centre of the room, is also important to ensure proper sequencing of the heater and fans. Thermostats should not be located in the path of air from an inlet, doorway or heater.

Air mixing chamber

The proper distribution of air in the building is provided by the polyethylene duct recirculation system. As a result, the location of the exhaust fans is not critical. Locating all the fans at one end of the building may be more convenient and cheaper to install, and will not affect air distribution (Figure 47).

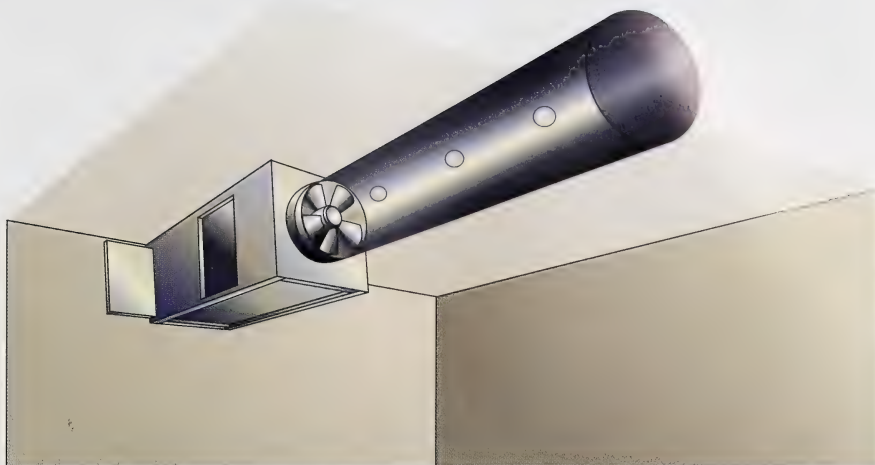


Figure 47. Air mixing chamber

Smaller storages (500 colonies or less) require very low airflow rates. It is often difficult to find a suitable fan in the size range required. Over-ventilating with too large a fan wastes energy and causes low relative humidities in the storage. One way to provide a small minimum airflow is to use one fan for both Step 1 and Step 2 ventilation. The fan is sized for the Step 2 rate and is operated intermittently by a timer to achieve a suitable Step 1 rate. For example, an adjustable 10-minute cycle timer set to run “ON” for 3.3 minutes every 10-minutes provides a Step 1 rate of 1/3 rated fan capacity and a Step 2 rate of full fan capacity.

The recommended air inlet size is 1 m^2 for every 5,000 L/s airflow. An inlet that is too small will restrict the exhaust fans and will cause reduced airflows. Too large an opening during cold periods will allow heat to flow out of the building under minimum ventilation. The maximum ventilation rate, Step 4, is approximately ten times the Step 1 rate. This rate requires the intake to be fully adjustable from maximum to minimum. The intake should be located close to the recirculation fan, so fresh air is well mixed and evenly distributed as it enters the storage.

The following Tables 7 through 10 offer design examples for ventilation with varying sizes of floor space and number of colonies.

Table 7. Ventilation Design Example for 100 Hives**Floor Space** – Approximately 25 m²

Fans	Recommended Airflow				Actual Airflow		
	(L/s)				(L/s)		
	Fan Capacity	Total Capacity		Recommended Fan*		Fan Capacity	Total Capacity
Step 1	25	25		BF-8, on 20%	} Same Fan	30	30
Step 2	50	75	One	BF-8		140	140
Step 3	100	175	Step	BF-8		140	140
Step 4	325	500		BF-10		235	375
Recirculation Duct – Airflow required: 500 L/s Recommended fan: BF2S-12 Poly tube: 380 mm diameter x length of room 40 outlet holes, 50 mm diameter required							
Intake Area – 0.1 m ² maximum, adjustable to 0.005 m ² minimum							
Heater Size – 1500 watts							
* All fan models refer to Hurst Equipment Ltd.							

Table 8. Ventilation Design Example for 300 Hives**Floor Space** – Approximately 75 m²

Fans	Recommended Airflow				Actual Airflow	
	(L/s)				(L/s)	
	Fan Capacity	Total Capacity	Recommended Fan*		Fan Capacity	Total Capacity
Step 1	75	75	BF-8, on 50%	} Same Fan	70	70
Step 2	150	225	BF-8		140	140
Step 3	300	525	BF-10		235	375
Step 4	975	1500	BF-16		1240	1615
Recirculation Duct – Airflow required: 1500 L/s Recommended fan: BF2S-16 Poly tube: 600 mm diameter x length of room 100 outlet holes, 50 mm diameter required						
Intake Area – 0.3 m ² maximum, adjustable to 0.015 m ² minimum						
Heater Size – 3000 watts (3 kW) <i>* All fan models refer to Hurst Equipment Ltd.</i>						

Table 9. Ventilation Design Example for 500 Hives

Floor Space – Approximately 125 m ²					
Fans	Recommended Airflow (L/s)			Actual Airflow (L/s)	
	Fan	Total	Recommended	Fan	Total
	Capacity	Capacity	Fan*	Capacity	Capacity
Step 1	125	125	BF-8	140	140
Step 2	250	375	BF-10	235	375
Step 3	500	875	BF-12	500	875
Step 4	1625	2500	BF-18	1745	2620
Recirculation Duct – Airflow required: 2500 L/s Recommended fan and poly tube: Option 1: one BF2S-20 fan with 600 mm poly tube, 140-50 mm holes. Option 2: two BF2S-16 fans with 600 mm poly tube, 100-50 mm holes.					
Intake Area – 0.5 m ² maximum, adjustable to 0.025 m ² minimum					
Heater Size – 5000 watts (5 kW) <i>* All fan models refer to Hurst Equipment Ltd.</i>					

Table 10. Ventilation Design Example for 1000 Hives

Floor Space – Approximately 250 m ²					
Fans	Recommended Airflow (L/s)			Actual Airflow (L/s)	
	Fan	Total	Recommended	Fan	Total
	Capacity	Capacity	Fan*	Capacity	Capacity
Step 1	250	250	BF-10	235	235
Step 2	500	750	BF-12	500	735
Step 3	1000	1750	BF-16	1240	1975
Step 4	3250	5000	BF-20	2310	4285
Recirculation Duct – Airflow required: 5000 L/s Recommended fan: two BF2S-20 Poly tube: two 600 mm diameter x length of room 140 outlet holes, 50 mm diameter required					
Intake Area – 1.0 m ² maximum, adjustable to 0.5 m ² minimum					
Heater Size – 10 kW <i>* All fan models refer to Hurst Equipment Ltd.</i>					

4. Light

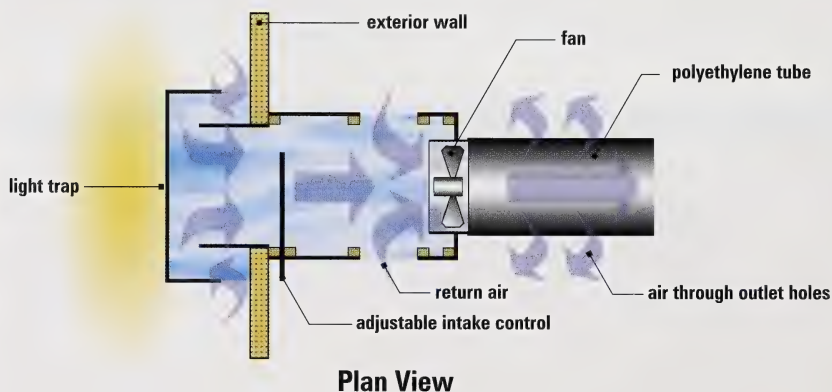
Build the storage room to exclude as much light as possible. Too much light promotes bee activity and makes storage much more difficult. This is particularly true in late spring when outdoor temperatures are warm, and the bees sense that spring is at hand.

White light bulbs should be replaced with red ones, as bees cannot “see” the lower red rays of the colour spectrum. This type of lighting will allow the beekeeper to work within the storage with little disturbance to the bees.

The most difficult place to exclude light is at the air intake and fan openings. Several types of light traps are used. The principle of most is to force the ventilation air to make several right angle turns. A common problem is that discharged air from the fan is often forced to make an abrupt sharp turn. As a result, the fan operates at a higher pressure and a considerably reduced airflow.

Figures 48 and 49 show a design that effectively eliminates the light and causes minimal restriction for the fan. The trap for the exhaust fan should be installed on the inside of the building since it will affect the fan performance less than if installed on the discharge side of the fan. Painting the interior surface of the light traps a flat black will minimize reflection, helping to exclude light. Table 11 shows the dimensions to use for fans of varying diameter.

Figure 48. Light trap for intake fan



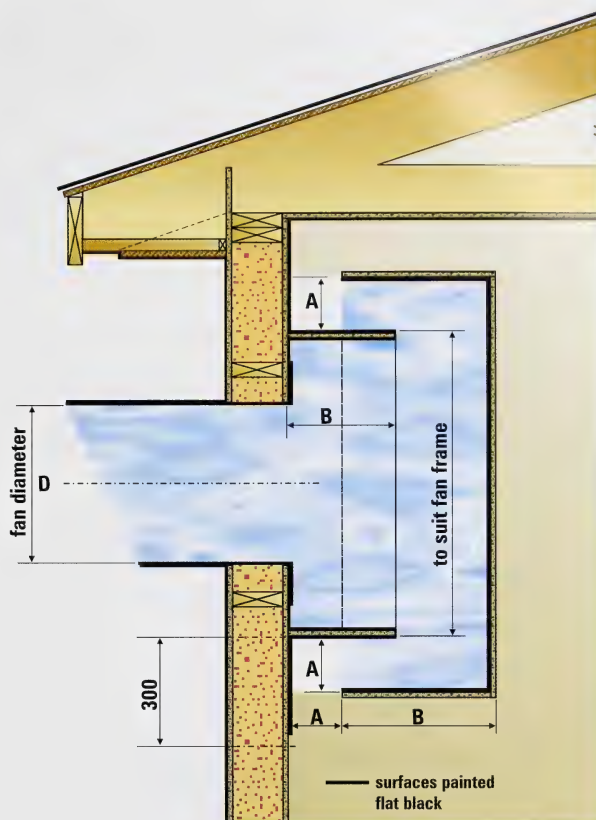


Figure 49.

Light trap for exhaust fan
and dimensions to use for
fans of varying diameter

Table 11. Fan Diameters

Fan Diameter (mm) "D"	Dimensions	
	(mm) "A"	(mm) "B"
200	25	75
250	38	115
300	64	200
400	100	300
450	125	375
500	150	450

Based on one light trap per fan open on four sides

Hive arrangement

Hives should be stacked in rows perpendicular to the air duct, with the rows spaced about 1 m apart to facilitate air movement.

Storage room floors should be swept periodically to dispose of dead bees. The dust caused by crushing the dead bees underfoot can often aggravate respiratory problems for the person(s) working in the building, or it can result in the development of allergies. Also, the dead bees may harbour fungal spores that could be harmful to human health. For this reason, face masks with filters should be used when working in the indoor wintering facility for long periods.

Feeding colonies indoors

At times, it may become necessary to feed bees sugar syrup while they are in storage. Frequently used feeding methods include gravity feeders, Boardman feeders and plastic honey containers (500 g size). To use honey containers, punch four or five small holes (3-4 mm in diameter) on one side of each container near the top rim. After the containers are filled with syrup and the lids fastened, they are placed inverted on the bottom board with the holes facing the hive entrance.

Indoor feeding may also require a modified hive stacking arrangement. A staggered or “off-set” stack that allows access to the top of each hive is needed if gravity feeders are to be used (Figure 50). If feeding is to be done through the entrance, the hives may be stacked directly on top of each other.

Figure 50.
Gravity feeders



The Queen

Natural Requeening

The role of the queen in brood production and colony cohesion has already been mentioned (see Chapter 1). Left to its own devices, a honey bee colony will initiate production of new queens whenever the amount of “queen substance” (queen mandibular pheromone) available to the colony falls below a critical level.

The anatomical and behavioral differences shown by adult workers and queens (which are both female) result from both quantitative and qualitative differences in the feed each receives during larval development. Larvae being reared as workers receive a surplus of food only up to about 2.5 days after hatching. After approximately 2.5 days, the worker larvae are fed the minimum required for their development.

The food fed to larvae being reared as queens is commonly referred to as “royal jelly.” One of the substances in royal jelly that affects the development of the larvae is the common insect hormone known as juvenile hormone. Research has shown that female larvae receiving juvenile hormone throughout their development will develop queen characteristics, whereas female larvae that do not receive this hormone throughout their development will develop into workers.

A honey bee colony will raise queens naturally under three basic circumstances or conditions:

Emergency queen rearing

Emergency queen rearing occurs when a colony suddenly becomes queenless as a result of the queen dying or otherwise being removed from the colony. When this situation occurs, the colony begins feeding large amounts of royal jelly to a few selected existing larvae in worker cells. The colony is thus able, under “emergency conditions,” to use the fertilized eggs in the worker cells as a source of replacement queens. This type of queen rearing typically shows up in the colony with the “peanut shaped” queen cells hanging down from the face of brood comb.

The colony is thus able, under “emergency conditions,” to use the fertilized eggs in the worker cells as a source of replacement queens.

Supersedure

Supersedure occurs when the existing queen begins to fail, usually as a result of aging, injury or disease. The affect on the queen is usually reduced egg laying capacity and a decline in queen substance. Under these circumstances, the colony will usually rear a replacement queen either from larvae in worker cells or larvae in queen cells.

Swarming

When a colony becomes large or congested in its current living space, queens will be reared in specially prepared swarm cells. Before these new queens emerge, the old queen will leave the colony, taking with her a portion of the existing adult bee population. One of the new queens will normally take over as the queen of the “parent” colony. Swarm cells are

typically located around the peripheries of the brood comb and along the bottom bars of the frames (Figure 51).



Figure 51. Swarm cells. Queen cells occurring on the bottom of frames usually indicate the colony is preparing to swarm.
(Photo D. Dixon)

Queen honey bee mating takes place aurally outside the hive. It is generally believed that the queen takes one to several mating flights during the first week after emerging as an adult. During these mating flights, the queen flies from the hive and releases a chemical attractant (pheromone) that assists drones in locating her. After mating with one or several drones, the queen returns to the hive and may or may not go on another mating flight before beginning to lay eggs.

Usually, once a queen has started laying, she will not go on any more mating flights. Therefore, continued egg fertilization depends on the quantity of spermatozoa acquired and stored in a specialized organ, the spermatheca, during the first few weeks of the queen's adult life. On average, queens produce fertilized eggs from one to three years, but individual queens may produce fertilized eggs for a shorter or longer time.

If the weather is not conducive to mating when the virgin queen is physiologically ready, she may begin to lay unfertilized eggs after about three weeks, which then develop into drones. Drone-laying also occurs when a queen has depleted her stock of sperm. A mated queen in prime condition can lay both fertilized and unfertilized eggs at will. When the queen inspects a cell she is about to lay an egg in, she measures the dimensions of the cell by using her forelegs as calipers. She lays a fertilized egg in a worker cell and an unfertilized egg in the larger drone cells. A drone-laying queen can be noticed immediately by the bullet-shaped cappings on all her brood, including the worker cells that have been built out by workers (Figure 52).



Figure 52. Drone cells appear as bullet-shaped protruding from the face of the comb, here surrounded by worker cells.
(Photo D. Dixon)

When a queen is failing and reducing her egg output, the colony will try to supersede her. However, if only unfertilized eggs are present, supersedure will not be possible, and a queenless condition will result. A queenless colony is immediately noticeable to the experienced beekeeper by its peculiar buzzing, described as a roaring sound. In addition, the workers in a queenless colony are usually agitated and run about on the frames, often with their wings spread. A further check will show a lack of eggs.

Queenless colonies and colonies with drone-laying queens may be requeened using one of the slow release methods described below. The old drone-laying queens must first be destroyed or the new queen will not be accepted. Very weak colonies are better off united with strong colonies that have a healthy queen (queen-right).

Laying Workers

When a colony is without a queen, there is no inhibitory effect of the queen substances on worker ovary development, and one or several workers may begin to lay eggs. The presence of many eggs deposited on the sides of cells in a disorderly arrangement, some upright and some lying flat, signifies the presence of laying workers. The disorder occurs because the workers' abdomens are too short to reach to the ends of the cells. This laying pattern should not be confused with that of a queen in prime condition held back from capacity by too small a cluster of bees; often such a queen will lay more than one egg in a cell, but these eggs are all deposited in the ends of each cell in an orderly manner.

Since workers cannot mate, their eggs will develop into drones, usually small from being raised in worker cells and from undernourishment. Once a queenless colony has laying workers, requeening will generally be unsuccessful. The beekeeper is then better off

shaking the bees in front of another colony or on the ground away from other hives and letting them drift to other colonies in the yard.

Requeening as a Management Tool

Wintered colonies should be requeened every one or two years as a part of colony management. Without regular requeening, the beekeeper ends up with a proportion of the colonies not operating at full capacity because of older and failing queens.

Allowing colonies to requeen themselves only through supersedure and emergency queen rearing will often result in some colonies dying as a result of queen failure in the winter. Others may not reach their maximum populations in the summer because of queen failures during the spring build-up period.

Some beekeepers prefer to requeen only those colonies that they notice need requeening; however, for optimum overall control of queen quality and productivity, the beekeeper should requeen at least 50 per cent of the colonies each year.

Colonies may be requeened at any time during the spring and summer seasons. The pre-flow period lends itself best to requeening, as brood chambers are being checked regularly in any case. Post-flow requeening can be just as successful in terms of queen acceptance but will take more time as colonies are very strong, and old queens are hard to locate. There is also the danger of inciting robbing at this time of year.

Methods of Queen Introduction

To increase the likelihood a queen will be accepted, colonies should be queenless for three to five days before a new queen is introduced. The queen to be introduced should be confined alone in a cage. This approach is used so that the bees cannot injure her but will be able to feed her through the screen while they are becoming acquainted with her presence in the hive.

New queens should be on hand when the colonies are unwrapped or moved outdoors, when the first spring checks are made in April and May. Colonies that are strong but queenless, or that have a failing queen as shown by poor brood pattern, drone brood in worker cells and a lack of brood should be requeened immediately.

- Queens can be confined alone in a screened cage with the exit opening filled with queen cage candy, an icing sugar and corn syrup mixture. There should be enough candy for the workers to take one or two days to eat their way into the cage to release the queen.
- The queen can be held under a shallow push-in cage made of 3 mm wire cloth, the edges of which are pressed lightly in the comb. Some cells of honey and emerging brood should be included with the queen. This cage should be removed in about three days, with as little disturbance as possible.



- The queen can be released directly after treating her with a light spray of vanilla extract (or some other aromatic substance) and sugar syrup. This result can be accomplished by placing the queen on the face of a frame among the workers and then immediately spraying the queen and surrounding workers with a light mist of the vanilla/sugar syrup mixture.

The spray apparently masks any foreign odours on the queen that may cause the workers to reject her. By the time the bees have cleaned up the spray, the queen is usually accepted. This method works best when the honey bee colony has been queenless for at least three to five days.

Banking Queens

When a large order of queens arrives, and the beekeeper cannot use them all right away, he or she may wish to store them in a queen bank. This bank is a strong, single storey queenless colony with a high proportion of young bees and plenty of pollen and honey or syrup.

A special holding frame for the cages is constructed with support and holding bars to contain two or three tiers of cages. The attendant workers are removed from each cage, and corks are left in each end of each cage. Cages are then placed in the holding frame, candy down, and the holding frame is placed in the queenless colony. The young workers will look after most or all of the queens. The population must be replenished weekly with young workers if the queen bank is to be used for an extended period. The subsequent performance of banked queens generally falls off in proportion to the length of time they were stored.

Queen Cage Candy

The candy used in queen cages can be made from icing sugar and corn syrup, using enough icing sugar so that the candy becomes stiff and does not stretch. A drop of glycerine will ensure the candy does not dry out.

Queen Rearing

Queens may be reared in late spring and summer, when nectar and pollen are abundant and colonies are strong with plenty of young bees for wax-building and royal jelly production.

Whether the beekeeper wishes to rear only a few queens for his or her own use or enough queens for sale to other beekeepers, the basic principles of queen rearing remain the same. Choose breeder queens that have the desired traits. Obtain young larvae from these queens and place them in cell-building colonies primed to feed and care for developing queens. Once hatched, queens must be cared for while maturing, mating and beginning to lay.

Any beekeeper interested in rearing queens should first consult the recommended references included in Appendix B (Laidlaw, Laidlaw and Eckert), which outline queen rearing in detail.

Characteristics
preferred by most
beekeepers are a
gentle temperament,
good wintering ability
and good honey
production.

Using naturally-produced queen cells

If only a few queens are needed, the beekeeper may wish to use queen cells from colonies that are swarming, superseding or queenless.

Swarming colonies are usually at their peak, with ample food stores and many young bees, and are thus able to raise well-fed queens. The beekeeper should choose the largest swarm cells from a colony with desirable characteristics and carefully cut the capped cells from the comb. Then, place the cells either in other colonies that have been dequeened or in mating nuclei. The main disadvantage in using swarm cells is in the possible perpetuation of the swarming trait.

Supersedure cells may also be used for new queens, if produced at the right time of year when a colony is in the peak of condition.

The beekeeper may raise queens by simply removing the queen from a colony and removing its queen cells 10 to 11 days later. Variations on this method lead to greater control by the beekeeper in the process of queen rearing by choosing breeder queens and giving their eggs to queenless cell builders as outlined below.

Breeder colonies

The breeder queen will be the mother of the new queens and should therefore possess all the traits the beekeeper wishes to retain in his or her stock. Characteristics preferred by most beekeepers are a gentle temperament, good wintering ability and good honey production. Other characteristics include disease resistance, lack of a tendency to propolize, compactness of the brood nest and desirable storage patterns.

If this queen is to be used as the breeder queen for any length of time, she is confined to a single super or to a nucleus. The breeder colony is provided with frames of capped and emerging brood and uncapped honey, and is fed continuously with a thin sugar syrup and pollen frames or supplement. A frame of foundation may be added to occupy bees of wax-secreting age. Young bees or emerging brood are added at least once a week. The queen is given an empty comb to lay in, generally a good-quality dark worker comb if grafting is to be done, or a light comb if cells are to be raised in and cut from this comb.

On the third day after laying, these eggs begin to hatch. From 12 to 24 hours later, they are of the correct age for use by the beekeeper in grafting or transfer to cell building colonies. An empty new comb can then be given every four days. Alternatively, the queen may be given a new comb each day by confining her in a frame-sized cage of queen excluder material. The comb of freshly-laid eggs is then placed outside the excluder or in an incubator colony until the eggs have hatched and the larvae are 12 to 24 hours old.

Cell building colonies

Cell building colonies are those that receive the young female larvae and raise them into queens. The cell building colonies may be queen-right, but are more commonly queenless. Commercial beekeepers use a combination of queenless cell starters and queenless or queen-right cell builders or finishers, the former receiving the newly grafted larvae and the latter receiving them 24 hours or more later.



To raise large, well-fed queens, the cell building colonies must be very strong and crowded with many young bees and drones and ample nectar and pollen. In short, cell builders bear a close resemblance to colonies that have the swarming impulse.

These colonies are prepared in the following manner:

- about a week before the colony is to be used, the queen is removed from a strong two- or three-storey colony and the bees shaken into one or two boxes
- the colony is carefully checked for queen cells a week later or the day before it is to be used, and these cells are destroyed
- the cell builder should hold frames of pollen and honey, capped and emerging brood, empty frames and a frame of foundation, which will occupy the wax-secreting bees
- at least one or two frames of brood are added each week to keep up its strength, and young adult bees may be added as well
- the cell builder is continuously fed with sugar syrup and frames of pollen throughout the queen-rearing period

Rearing queens without grafting

To rear queens without grafting, the breeder queen is given an empty worker comb, preferably light in colour, for egg-laying. When the eggs begin to hatch about three days later, this comb is transferred to the cell building colony, prepared nine days earlier as outlined above. Two days later, the comb is checked for queen cells, and those present are marked by inserting a small nail into the comb above each cell, being careful not to damage the cells.

About a week later, the comb is checked again, and any unmarked cells are destroyed, thus ensuring that queens are produced only from younger larvae. No later than nine or ten days from the comb's introduction to the cell builder, the comb is removed, and the cells are carefully cut from the comb and placed in mating nuclei or previously dequeened colonies. The queens will emerge in two or three days and with good weather, will be mated and laying within two weeks.

Other methods of rearing queens without grafting involve more manipulation and cutting of the comb, and these approaches are outlined in references in Appendix B (Laidlaw, Laidlaw and Eckert). Some of these methods can be used to rear large numbers of queens successfully.

Rearing queens by grafting

The system of rearing queens by grafting is usually used for large scale queen rearing. The method involves grafting or transferring larvae of uniform age from worker comb to queen cups, which are previously prepared and attached to the removable bars of a cell-holding frame. Breeder and some combination of cell builder, starter and finisher colonies are used. Queens can be reared for several weeks by following an orderly, day-to-day schedule.

Queen cups are prepared by constructing cell dipping sticks made from lengths of 9.5 mm dowelling, rounded and smoothed at one end with sandpaper. The correct size may be tested by fitting the rounded end into a natural queen cup. A series of these cell dipping sticks may be made up and attached to a strip of wood, or a single stick may be used alone.

Cell cups are then formed by dipping these forming sticks into cold water, then into melted wax to a depth of about 1 cm, allowing this first wax coat to harden, and then dipping

several more times, each time to a shallower depth. After immersing in cold water, the wax cup is removed with a gentle twist. About 15 queen cups are fastened to each cell bar with melted wax. Commercial queen cups are also available.

The grafting room should be at least 24°C and high in relative humidity to prevent dehydration of the young larvae. A fluorescent table lamp gives satisfactory lighting without giving off heat. The breeder colonies and cell builders should be located nearby. Alternatively, grafting may be done in the apiary in the front seat of the truck if adequate relative humidity is maintained.

Grafting can be done with a variety of tools, and with experience, each beekeeper will find the most suitable one. Commercial grafting tools are available. Some beekeepers flatten and sand the bent tip of a piece of copper wire for grafting, while others may find that fine sable-hair paint brushes work well.

Before grafting, cell bars should be prepared and the queen cups primed with a 50 per cent water: royal jelly solution to prevent desiccation and to aid in floating the young larvae off the grafting tool. A frame containing newly-hatched larvae is taken from the breeder or incubator colony to the grafting room. The light should be adjusted so that larvae are easily visible. The grafting needle is slipped under each larva, which is then lifted from the cell and transferred to the queen cup. In the queen cup, it is floated off the needle on its own royal jelly or onto a previously primed jelly bed.

Once each cell bar is completed, it is placed upright in the holding frame and covered with a damp cloth. When the holding frame is filled, it is carried upright to the cell builder and turned very carefully just before placing between a frame of pollen and a frame of brood. If the grafting is slow, each bar should be placed in the cell builder as it is completed, to prevent chilling and drying of the larvae.

Developing queens are susceptible to injury through careless handling. Holding frames must never be shaken to remove bees; rather, bees should be gently brushed off with a soft bee brush. Shaking and jarring may dislodge larvae from their bed of royal jelly and may damage the developing pupae.

When queen cells are ripe (Figure 53), they may be removed from the cell builder and either incubated overnight or taken directly to mating nuclei or dequeened colonies. Cells are usually removed at nine or ten days after grafting. Care must be taken so that the cells are not chilled or overheated; a small cooler containing a hot water bottle and a sponge or styrofoam block with holes to hold the queen cells may be used for transport. Cells must be kept in their proper orientation with the capped tip pointed downwards, or the developing queen may be dislodged and injured.



Figure 53. Mature (ripe) queen cells, on cell bar frame, ready for use in mating colonies or in colonies to be requeened.

Queen mating colonies

Mating colonies range from miniature nuclei to full-sized colonies requiring a new queen. Nuclei can be made up of standard depth supers divided into two bee-tight sections, each holding four frames, with individual entrances facing in opposite directions and covered with sacking so that each nucleus can be worked separately. Each nucleus contains a frame of honey, a frame of brood, and two relatively empty frames, all with accompanying bees.

Nuclei may be moved to a separate yard to prevent drifting back to parent colonies. If left in the original yard, they should be moved away from the parent colonies and reoriented. Mating nuclei must be arranged in such a way as to aid the queens in orientation, with plenty of landmarks and entrances facing in different directions.

Honey Bee Health

Numerous diseases, predators and conditions affect the health and vigor of the honey bee colony. The beekeeper must know the appearance of healthy bees and brood (Figures 54 and 55) so that deviations from the norm will be recognized. Knowing the symptoms of the common diseases will be worthwhile in diagnosis and treatment. A quick check for abnormal brood and adult appearance and for signs of unwelcome predation is a part of regular colony maintenance.

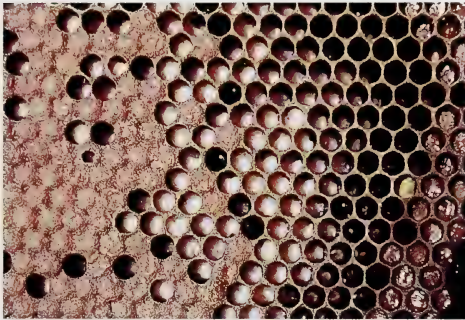


Figure 54. Healthy frame of brood. A band of pollen is present between the honey and uniformly capped cells.

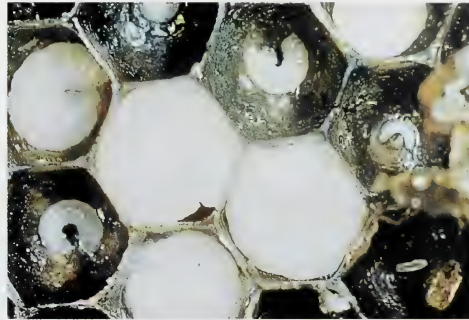


Figure 55. Healthy larvae in various stages. (Photo M. V Smith)

Honey Bee Brood Diseases

American foulbrood

American foulbrood (AFB), caused by the bacterium *Bacillus larvae* (recently reclassified as *Paenibacillus larvae* var. *larvae*), is probably the most serious of all the honey bee brood diseases. If unchecked, AFB can spread in and amongst colonies, causing severe weakening and colony death. Spores of the bacterium remain viable for many years and are capable of causing fresh outbreaks whenever conditions are favorable. The provincial Bee Acts were first written mainly to control the spread of AFB, and disease inspection programs continue to the present day.

Life Cycle and Spread of AFB

Infection begins when the young larva ingests AFB spores along with its brood food. Larvae appear to be most susceptible when under three days old: as they grow older, they become resistant to infection. Spores germinate and the vegetative forms reproduce in the larval gut, migrating into the tissues of the larva and continuing to multiply there while feeding on the tissues. The bee dies in the prepupal or early pupal stage, after the cell has been capped. Death is due to toxins released by the bacteria, which begin to form more spores once the larval tissues have been utilized. The remains of one dead larva hold an estimated 2.5 billion spores.

The dead larva is eventually uncapped by house bees trying to clean out the cell. In doing so, spores contaminate their mouth parts and are spread throughout the hive from bee to bee and eventually to more young larvae. The adults themselves are not affected by AFB.

American foulbrood is spread among colonies through robbing and drifting bees. Often, a colony weakened through disease cannot defend itself and is completely cleaned out by robbing bees, which may then carry AFB spores back to their own colonies. The disease may also be spread by the exchange of equipment among colonies when equalizing colony strength or making up brood chambers and even when buying and selling infected equipment.

Pollen and honey may carry AFB spores and, therefore, should only be fed to bees when from disease-free colonies. Package bees from infected colonies can carry enough AFB spores with them to cause a new outbreak of AFB in the new hive they are placed in.

Symptoms

As the larval tissues break down, they turn a uniform coffee color and lose all resemblance to a larva, eventually forming a gooeey mass (Figure 56).



Figure 56.

Larva dead from American foulbrood after being capped over, cross sectional view.

(Photo M. V. Smith)

Since the larva dies after capping, the decaying mass is stretched out in the bottom of the cell rather than coiled up in the position of a younger larva. At one stage, the dead larva will exhibit some ropiness if drawn out with a toothpick or stick (Figure 57). If the remains are not removed, they dry into a flat brown or black scale, adhering tightly to the bottom of the cell (Figure 58). This scale is the stage containing the dormant spores. Occasionally, the pupal tongue remains upright.



Figure 57. Ropiness, characteristic of American foulbrood disease.
(Photo M. V. Smith)



Figure 58. American foulbrood scale on floor of cells.

Advanced stages of AFB will exhibit a spotty brood pattern and the presence of dark brown, sunken and punctured cappings (Figure 59). This appearance is due both to the uncapping of dead larvae by the house bees and to the queen's reluctance to lay in cells containing scale. A distinctive odor, which smells somewhat like rotting fish, may be present.



Figure 59.
Spotty brood pattern
indicating American
foulbrood.
(Photo S.E. Bland)

Diagnosis, Prevention and Treatment of AFB

A positive diagnosis is made by examining dead larvae and scale under a microscope for the presence of AFB spores. Samples for examination may be sent to the apiculture office. Samples of dead larvae or scale may be sent in wax paper in an envelope, or a small piece of comb may be cut from the suspect frame and sent in a box or other container.

The first step in American foulbrood control is to prevent its establishment in colonies. Prevention techniques include the purchase and use of disease-free equipment, the storage of equipment in bee-tight buildings and management techniques that minimize robbing and drifting.

The antibiotic oxytetracycline is useful both in preventing colony breakdown with AFB disease and in treating infected colonies after visible signs of the disease have been removed. Oxytetracycline may be fed to colonies as a preventative measure. Should AFB

spores then be brought into the colonies, the disease does not establish itself as long as the effects of the antibiotic are present.

Along with spring and fall feeding of oxytetracycline, the beekeeper should regularly examine combs of uncapped brood for discoloured larvae, the first indication of disease. Whenever combs are to be exchanged among colonies, they are checked first, and when brood chambers are made up, each comb is carefully examined for evidence of scale or fresh breakdown.

When looking for scale, hold the frame with the bottom bar pointing away, at such an angle that the bottom side of the cell is clearly visible. Good light is essential, especially when inspecting dark combs. Sunlight or a 200 or 300 watt light bulb are recommended light sources.

Diseased colonies require both immediate and long-term treatment. If the diseased colony is strong, frames containing infected brood should be removed and the colony treated with oxytetracycline. Treatment should be given weekly until six weeks before the honey flow and again after the flow. A colony weakened from a severe case of AFB should be killed, and the dead bees and combs burned. Infected brood combs may be melted down to salvage the wax but must never be exposed to bees in the meantime.

Infected equipment should be operated separately for at least two disease-free years. The quarantine yard is treated with oxytetracycline and observed closely. Frames containing honey and pollen are rotated so that the stores are used up, allowing the bees to clean out each comb while being fed oxytetracycline. Any combs showing fresh breakdown are culled and burned or melted down. American foulbrood disease can be controlled and effectively eradicated over several years with constant vigilance, regular inspections, removal of infected combs and appropriate feeding of drugs.

European foulbrood

European foulbrood (EFB) is a brood disease associated with a complex of bacterial organisms. The bacterium *Melissococcus pluton* (formerly *Streptococcus pluton* White) is the main causative organism, while secondary bacteria such as *Bacillus alvei* enter and feed on the tissues of the dead larva. EFB is not usually a serious brood disease although under certain conditions, it can be quite severe.

Life Cycle and Effects of EFB

Typically, EFB kills young larvae (less than 48 hours old), but occasionally, older larvae may also die. The bacterium is ingested with the brood food and multiplies in the larval gut, occupying the space between the food and the gut lining and competing with the larva for food. Within five days, the larval mid-gut is full of bacteria, which effectively starve the larva. Nurse bees will eject some of these larvae that have an abnormally high demand for food.

Larvae infected with EFB generally die in the curled stage before capping occurs, although death sometimes occurs after capping as well. While cleaning out the cells, house bees become contaminated with *M. pluton* and pass it on to other adults and larvae. If the larval remains are not removed, they will dry into a scale and be a source of future infection. The disease can spread from colony to colony through robbing and drifting, exchange of hive equipment, feeding pollen from diseased colonies and installation of infected packages (similar to the spread of AFB).

European foulbrood appears in colonies primarily in spring and early summer; the onset usually coincides with the first nectar flow. If the disease is severe, it may prevent colonies from reaching full strength in time for the main nectar flow. Stresses such as brood nest expansion, inclement spring weather and moving colonies for pollination may be factors involved in the appearance of EFB.

Symptoms of EFB

Because the larvae usually dies before capping, dead larvae appear curled and contorted (Figures 60 and 61). The larval color changes first from pearly white to translucent and then to yellow and brown. In addition, the tracheae or breathing tubes may become apparent in each segment and along the sides as silvery lines (Figure 60). Larval scale retains the curled shape and is easily removed from the comb (as opposed to AFB scale, which adheres to the cell wall).



Figure 60.
Larvae killed by European foulbrood prior to capping over. The silvery tracheae can be seen in the larva at the bottom left.
(Photo M. V. Smith)

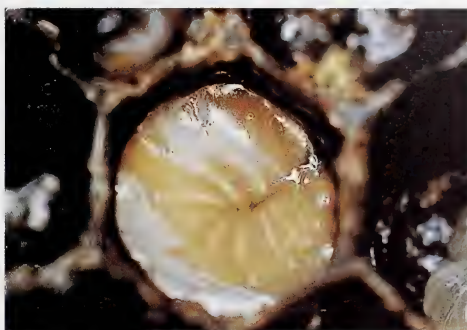


Figure 61.
Close-up of European foulbrood killed larva.
(Photo M. V. Smith)

In severe cases, a spotty brood pattern and a sour odor may be present. Some death does occur in the stretched-out stage (Figure 62), and these larvae may resemble larvae killed by AFB, so care must be taken to distinguish the two diseases by searching for more definitive symptoms.



Figure 62.
Larva killed by European foulbrood in the prepupal stage after capping. This may be confused with American foulbrood.
(Photo M. V. Smith)

Heavily infected colonies should be isolated, and equipment quarantined and kept separate. Frames containing more than a few infected larvae may be removed and destroyed. Since oxytetracycline is effective against European as well as American foulbrood, diseased colonies are treated with oxytetracycline and are marked for further inspection and treatment (see Appendix E, Recommendations for Feeding Antibiotics).

Chalkbrood

Chalkbrood was first discovered in Canada in 1971. Since then, the disease has spread across the country and is found in every province. Chalkbrood often increases in intensity in the spring and early summer, causing increased brood mortality but only rarely is it severe enough to cause economic impact. Chalkbrood is often associated with increased stress on the colony such as increased brood rearing and inclement weather.

Chalkbrood is caused by a fungus, *Ascosphaera apis* Maassen ex Claussen (Olive et Spiltoir), which has female and male forms. Either form can infect and kill honey bee larvae, but both forms must be present for spores to be produced. The spore is the dormant, resting stage.

Spores are ingested by the larva, which is most susceptible to the disease at three to four days of age, and germinate in the digestive tract. Growth of the vegetative form, the mycelium, occurs out of the hind end of the gut once the larva has been capped over. The dead prepupa looks white and fluffy at first but quickly dries down to a hard, shrunken, chalklike “mummy,” white or grey to black as spores are formed on its surface (Figure 63).



Figure 63.
Chalkbrood killed larvae
showing both white and
grey “mummies”

The worker bees eventually uncap and remove these mummies (Figure 64), which can then be found on the bottom board and around the hive entrance. Spores, viable for up to 15 years, may remain in hive equipment and serve as a source of reinfestation. Generally the highest infection levels are found in mid-June.



Figure 64.
Chalkbrood mummies
exposed in the comb after
uncapping.

Chalkbrood is a disease that commonly appears when the colony is under stress from other factors. A high level of spores may be present with no symptoms of the disease occurring in a strong and otherwise healthy colony, whereas a weak colony may break down.

The incidence of chalkbrood varies from year to year and from region to region. In most cases, the colony shows only a few chalkbrood mummies in the late spring, and the symptoms disappear in the summer. However, some colonies may have many mummies in brood combs, on the bottom board and in front of the hive, with a corresponding decrease in amount of capped brood.

No chemical is registered in Canada for use against chalkbrood. As with other stress-related diseases, proper management and strong healthy honey bee colonies are the best means of prevention and control of chalkbrood. Spores may be spread via adult and immature bees, the queen, pollen and equipment from infected hives.

Shipment of queens and package bees throughout the United States and Canada has been suggested as one explanation for the wide and rapid spread of the disease. Pollen for feeding back to bees should not be trapped from colonies with chalkbrood or any other disease. Old brood combs with a high number of mummies may be destroyed, and sheltered apiary sites with good air drainage should be used. Poor ventilation and moisture accumulation may be avoided by the addition of an upper entrance to wintering colonies. Severely affected colonies may be killed or requeened, as some genetic susceptibility may exist.

Sacbrood

Sacbrood is a viral disease of the brood that tends to appear in colonies in the spring and early summer build-up period.

Symptoms include uncapped or partly uncapped dead larvae/pre-pupae scattered throughout the brood area and capped cells in areas where brood has emerged. Sacbrood might be mistaken for foulbrood because the larva changes colour from white to a darker colour as it begins to die. Closer examination of dead individuals will reveal they have not sunk into the bottom of the cell, but instead appear bloated (Figure 65). If carefully removed from the cell, a sacbrood larva retains its shape (Figure 66). It is not possible to remove a larva dying of foulbrood from a cell intact. With sacbrood larva, the skin is hardened and leathery and appears to be fluid-filled. The head changes color to a dark brown, followed by

a darkening of the rest of the body. There is no gooeyness or ropiness with sacbrood, in contrast to foulbroods.



Figure 65.
Cross-section showing a sacbrood killed larva. Note the bloated appearance and darkened head, characteristic of the disease.
(Photo M.V. Smith)



Figure 66.
Fluid-filled sacbrood larva upon removal from the cell. Larvae are removed easily, unlike American foulbrood.
(Photo M.V. Smith)

There is no chemical treatment for sacbrood. As with all honey bee diseases, management techniques that minimize stress will help. Sacbrood virus is apparently only infective for a short time; breaking the brood cycle may therefore also break the disease cycle. Heavily-infected colonies may be requeened with less susceptible stock. Alternatively, the queen can be placed in a cage and prevented from brood rearing for three to five days. While sacbrood disease is not considered too serious, occasional severe outbreaks have been reported.

Adult Honey Bee Diseases

Nosema disease

Nosema disease is caused by a single-celled protozoan *Nosema apis* Zander. Because nosema affects adult honey bees, it is not as easily detected as some of the brood diseases that exhibit decaying larvae, ropiness, foul odors and other notable symptoms. The beekeeper is often unaware colonies are suffering from nosema until the disease is well-established and the damage done. Yet nosema has been described by some authors as being more economically damaging than all the other bee diseases common in North America put together. Nosema disease affects every segment of the beekeeping industry, from queen and package producers to crop pollinators and honey producers.

Life cycle and effects of nosema

The dormant stage of *Nosema apis* is a long-lived spore that is resistant to dehydration and temperature extremes. Spores are ingested by the adult bee and pass through the honey stomach to the ventriculus or true stomach. There, the spores germinate and enter the cells of the gut lining, where they multiply and eventually fill each cell with new spores. These cells are then shed into the ventriculus and burst, releasing the spores to invade new cells and to pass out of the bee in its feces.

Should defecation occur within the hive, the spores are picked up by house-cleaning bees and spread to other bees during food sharing. Once flying weather prevails, infected bees will defecate or die away from the hive, thereby lessening the chances of infecting other bees.

Honey bee colonies are most susceptible to nosema when the population is small or made up of old bees and when replacement is slow. Colonies are susceptible in the early spring in wintered colonies and in the first month after hiving packages. The incidence of the disease varies through the year, with a major peak in late winter and spring, low levels during the active summer season and a gradual build-up in the fall.

Nosema impairs digestive processes and causes premature aging and death in worker bees. Essentially, infected bees starve to death because they cannot digest any food. Nosema causes the hypopharyngeal glands, which produce protein-rich royal jelly, to atrophy; thus, brood rearing is curtailed. Severely infected bees look swollen and act as though in a stupor, crawling about in the hive or in front of the hive with wings unhooked.

Nosema can be found in drones and the queen and will cause degeneration of the queen's ovaries, resulting in supersedure or queenlessness. Nosema is probably the major cause of queen supersedure in package colonies.

These effects on the queen and on the workers will lead to a dwindling of the adult population, curtailed brood rearing and queen problems, all of which lead to reduced honey yields.

Diagnosis, Treatment and Prevention of Nosema

The only positive diagnosis of nosema disease is to examine the contents of the bee's digestive tract for the presence of spores. Examination may be done by the beekeeper if a compound microscope is available, or a sample of bees may be sent to the apiculture office (sampling procedure described later in this section).

The antibiotic fumagillin is effective against *Nosema apis* in both package and wintered colonies. A combination of good management and the regular use of fumagillin will keep nosema incidence to a minimum. The best natural defense is a strong healthy colony, with a prolific queen and plenty of young bees to replace any dying bees. Food stores must be adequate at all times. Apiary sites should be sheltered from wind and have good air drainage.

Nosema may be present in packages shaken from infected colonies. To ensure against a nosema outbreak and queen problems, fumagillin should also be fed in syrup to newly-hived packages.

Control of nosema disease in the overwintering operation will take a minimum of two years of feeding medicated syrup in the fall to repress spring outbreaks. With fumagillin, spore levels will drop each spring until the disease level is not economically damaging. Further feeding of fumagillin each fall will keep nosema in check.

To control the disease, the colonies should be given fumagillin in the fall feed. The medicated syrup will be stored in the combs and will retain its antibiotic activity through the winter, suppressing the build-up of spores and preventing a spring outbreak of nosema disease.

The best time to sample overwintered colonies for the presence of nosema spores is in the March-April period. At this time, nosema spore levels will be at their highest. Sampling may also be done in the early fall.

Sampling for nosema

Every colony may be sampled if the beekeeper owns only a few colonies. Otherwise, every second or third colony in a yard is sampled. This sampling is done by blocking the entrance for a few moments and picking off about ten bees and placing them in a container or placing them directly in alcohol (rubbing alcohol or ethanol). It is not necessary to keep bees from each colony separate. Field bees are taken rather than house bees.

Samples are sent in cardboard containers or in alcohol to the apiculture office immediately upon collection. Plastic bags, prescription bottles and so on should not be used as they allow the development of other organisms that break down bee tissues and obscure the presence of nosema spores. Results of the diagnosis can be used to predict the need for fall feeding of fumagillin to that yard only or to the whole operation.

Bee paralysis

Symptoms of bee paralysis are only occasionally noted by beekeepers, generally in a single colony in an apiary. Adult worker bees appear hairless, greasy or shiny and black with disjointed wings and distended abdomens. They are unable to fly, seem to have some paralyzed legs and exhibit crawling and trembling behavior. Healthy bees attempt to remove the crawlers from the hive, and large numbers of dead and dying bees may be around the hive entrance.

This disease is caused by a virus, and there is variability in genetic resistance by honey bees to virus infections. Thus, requeening will likely clear up the disease in the affected colony. Alternatively, if the colony is terribly weakened, the bees may be destroyed. Bee paralysis is of little economic importance in Canada and is rarely seen.

Bee paralysis is of little economic importance in Canada and is rarely seen.

Anomalies in Colony Condition

The honey bee colony may show conditions not caused by disease organisms but that may superficially resemble the foulbroods. Close examination should always be made of brood or adults that do not appear healthy to distinguish between disease symptoms and symptoms of any of the following conditions.

Gassed brood

When colonies are intentionally destroyed using calcium cyanide, the uncapped brood may be killed either by cyanide or by subsequent chilling or starving. Capped brood is somewhat protected from cyanide fumes and often hatches out even after the adults have been killed. Dead brood darkens and degenerates and may look as though it died of disease. When there is doubt, take samples to the apiculture office for examination.

Starvation

Starvation is especially common in the spring build-up period. Both adults and brood will suffer if there is not enough food in the hive. Lack of food or a reduction in adult numbers will cause house bees to remove brood from the combs and eat it or drop it in front of the hive entrance.

A pollen shortage may be recognized (too late) by the presence of dead pupae in front of the hive. Severe food shortage will cause starvation in the adult population. Slow-moving and trembling bees, along with empty honey frames, signify the colony is on the verge of death. Once the bees show these symptoms, they take a long time to recover.

Dying bees crawl head-first into cells where they remain after death. Warm 2:1 sugar syrup should be sprayed over the bees and in empty combs next to the cluster to revive starving bees.

Starvation can easily be prevented, first by supplying adequate food stores before winter and secondly, by supplying more food in the spring or whenever necessary. Early spring checks must be made to determine when feeding will be necessary. The colony should have at least 14-18 kg honey (five or six honey frames) at all times. A lack of capped honey at any time, especially during the brood rearing period, means the colony must be fed immediately. The adult population can starve in as little as 12 hours.

Dysentery

Honey bee adults normally void their feces when in flight and do not defecate when confined to the hive. If bees are confined over a long period and are feeding on poor quality food stores, the accumulation of large amounts of indigestible matter and water in the rectum will cause defecation in the hive.

Dysentery symptoms include spattered entrances and frames. Dysentery may be a factor in the premature death of adult bees, thus weakening the colony. Avoid poor quality food for winter stores, including frames of high moisture or granulating honey, burnt honey, honeydew, or syrup made from other than refined sugar (see Chapter 4).

Mites

Several species of mite are parasitic on honey bees. Some species live externally on honey bees but apparently do no harm. Two of the parasitic mites are currently found in Canada. Both are serious pests that, if not controlled, will affect adult longevity, brood production and honey production. Eventually, they will cause the colony to die.

Both the varroa mite and the honey bee tracheal mite are difficult to detect without close examination, and they spread rapidly within an apiary by drifting bees.

Varroa disease

The mite *Varroa jacobsoni* Oudemans is a honey bee parasite native to southeast Asia. It has been widely distributed throughout the world as a result of the unrestricted movement of honey bees by humans.

Varroa parasitizes both brood and adult honey bees. Female mites lay eggs in the cells of late instar (late moult) larvae, preferring drone larvae but parasitizing workers as well. The mite nymphs feed on the haemolymph (blood) of the larvae and pupae by piercing their body walls (Figure 67).



Figure 67.
Varroa jacobsoni feeding
on developing pupa.
(Photo Akratanakul)

As mite numbers in a colony increase, more than one adult mite will reproduce in a brood cell. When this happens, damage and loss of haemolymph causes weight loss and may cause the death of the immature bees, or the bees may hatch abnormally small and with deformed wings.

Adult mites attach themselves to adult honey bees and often crawl between the overlapping abdominal plates (Figure 68), where they are difficult to see and impossible to dislodge. There, the mites feed on adult haemolymph, causing weakening and some mortality. When there is no brood production in the hive, such as in the winter, adult mites will remain on the adult bees.

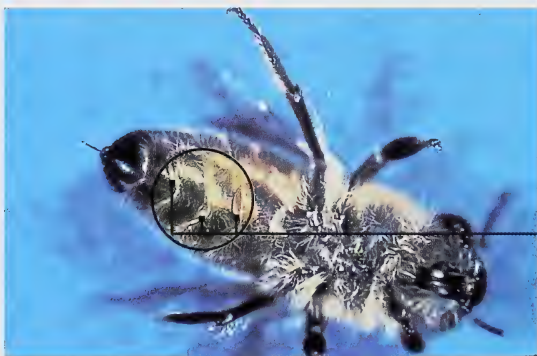


Figure 68.
Varroa mites between
abdominal plates.
(Photo H. Laidlaw)

A heavy varroa infestation will result in the dwindling, weakening and eventual death of honey bee colonies. Symptoms are not easily noticeable in the early stages; however, after some time, the beekeeper will notice poor build-up and a general weakened condition of the colony. By this point, the mites have likely spread within and amongst apiaries. To see the mites, adult bees must be examined, and brood must be uncapped and removed from cells.

The best method to detect early varroa infestations is to place a sticky board (stiff white paper or plastic sheet) on the bottom board. The sticky board should be covered with a wire screen (8 mesh/inch) to keep bees from the board. The hive is treated with formic acid or a fluvalinate strip. The board is removed and examined for mites 24 hours later. Adult varroa mites bear a superficial resemblance to the bee louse (*Braula coeca*) (Figure 69).

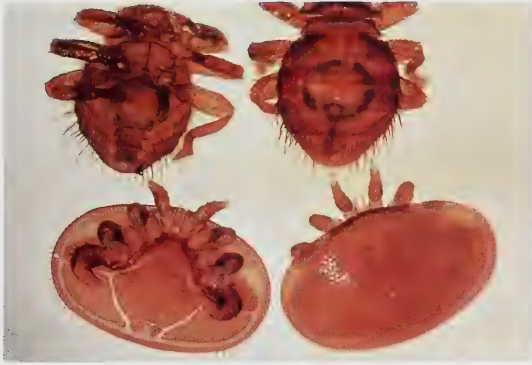


Figure 69.

The varroa mite (bottom), *Varroa jacobsoni* compared with the bee louse (top), *Braula coeca*.

(Photo H. Laidlaw)

Once varroa become established in a hive or apiary, they are virtually impossible to eliminate. Varroa can be controlled with treatments using formic acid or fluvalinate impregnated strips. Consult your provincial apiculturist for treatment details. Annual treatment of hives is essential to keep varroa at low levels and will prevent colony mortality and maintain productive hives. Varroa cannot live for many days away from live bees, so killing colonies and using cold storage for equipment may be effective, providing a varroa-free source of replacement bees is available.

Acarine disease/tracheal mite

The honey bee tracheal mite, *Acarapis woodi* (Rennie), spends its entire life on the adult honey bee (Figure 70). Adult female mites transfer from one host bee to another by clinging to their hair. Once on another young bee, they move into the main thoracic tracheae or breathing tubes or occasionally to the bases of the wings.

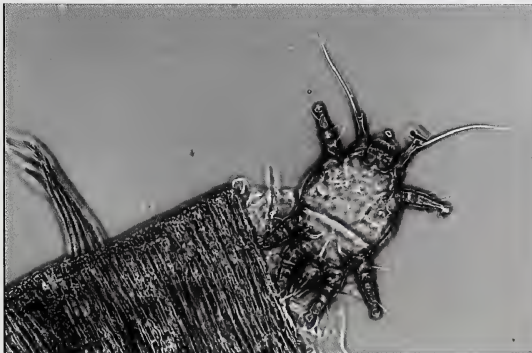


Figure 70.

Microscopic enlargement of adult mite leaving tracheal tube.

The mites feed on the bee's haemolymph (blood) by piercing the tracheae with their mouthparts. Within a short time after infesting a new host, eggs and young mites are present. Growth and mating take place within the tracheae, and new adult females leave to find another host. The mites cause some damage to tracheae, flight muscles and nerves and likely affect oxygen uptake by the bee, thereby shortening the bee's life span. Acarine disease caused by the mites appears to cause weakening and dwindling of colonies especially in winter, contributing to winter losses.

The honey bee tracheal mite has been found in Canada since the late 1980's. Mites spread within an apiary by drifting bees. Within two to three years after an apiary becomes infested, mite populations will increase to levels that begin to cause serious damage to colonies. The mites cannot be seen by the naked eye, and colonies do not display any symptoms that can be used for field diagnosis until the infestation becomes severe. A positive diagnosis can only be obtained by examining the prothoracic tracheae under a microscope for the presence of mites.

Tracheal mites can be controlled, but not eliminated, using formic acid or menthol treatments. Consult your provincial apiculturist for treatment recommendations. Annual treatments in spring or fall will ensure strong colonies and will minimize the effect of the mites. If they are not controlled, the bee colony population will dwindle, honey production will eventually be affected and winter mortality will increase.

Other parasitic mites

Two other mites are found on *Apis* bee species in tropical Asia.

- *Tropilaelaps clareae* Delfinado and Baker (Figure 71)
- *Eugarroa sinhal* Delfinado and Baker

As yet, these mites have not been reported in northern Asian, European or American countries.



Figure 71.
Adult of *Tropilaelaps clareae*.

External mites

There are three named species of *Acarapis* that live externally on adult honey bees.

- *Acarapis externus* Morgenthaler
- *A. dorsalis* Morgenthaler
- *A. vagans* Schneider

These mites are widespread and are probably present wherever honey bees are kept. These mites do not appear to harm the honey bees.

Insect Pests of Honey Bee Colonies

Ants

Ants are a major honey bee colony pest in tropical and warm temperate climates and may, occasionally, be a severe problem in colonies in Canada. If ants enter hives to find food, they are difficult pests for the guard bees to catch and remove. A continual stream of ants entering the hive will anger the bees and put the colony on the defensive. The ants may even decimate the colony population.

Species such as carpenter ants may cause structural damage to hive parts, especially bottom boards. Some ant species tend to start nests in the warm, protected space between inner and outer covers. These ants do not generally bother the bees below but constitute a nuisance to the beekeeper.

If ant nests are found in the apiary, they may be destroyed with gasoline, diesel oil or insecticide. Diazinon as a two per cent dust may be used under the backs of hives. Take care that the chemical does not come into contact with the bees or brood.

Chlorpyrifos granules also kill ants. Bottom boards must be solid so that the bees are not exposed to the pesticide, and hives should be up off the ground. Commercial ant bait traps are available that can be placed under the appropriate hives or along ant trails.

Wasps

The beekeeper can often notice wasps hovering around hive entrances and exposed supers. Bees usually manage to overcome the occasional intruding wasp quite effectively, and wasp predation on honey bees is not a threat to honey production under our conditions.

Wax moths

Two species of moth feed specifically on pollen, honey and hive debris. These wax moths can be a problem in stored hive equipment and occasionally in weak colonies. The female moth lays eggs on comb, preferring dark combs to light. The larvae or wax worms tunnel through combs, consuming pollen, honey and debris. In addition, they disturb and damage the honey bee brood, breaking up the structure and integrity of the combs. Wax moth larvae are extremely destructive, destroying many combs in a short time.

Generally, wax moths are not a problem in areas where hive equipment is stored over winter at sub-zero temperatures. If hive equipment is stored through the summer or in a heated shed in the winter, it seems to be only a matter of time until wax moths find it. As a precautionary measure, such equipment should be stored in "moth-tight" stacks with lids, and cracks between supers should be taped up. Paradichlorobenzene crystals or mothballs can be sprinkled on paper between each super to repel the moths.

If moths are found in stored equipment, all debris and webbed comb, which harbor the different life stages, should be destroyed. Expose the hive equipment to sub-zero temperatures to kill the moth larvae. The use of vapona for wax moth control is not recommended. Beeswax will absorb the vapona vapours permanently, and subsequent use of the combs will kill bees and brood.

Wax moths may ruin comb honey both on the hive and in storage. Comb honey should be removed from the hive when capped and should be stored at cold or freezing temperatures

for wax moth control. The best control is to use all hive equipment annually as the bees will keep it free of wax moths.

Several other species of moth that feed on stored products, such as grain and dried fruit moths, are common pests in stored bee hive equipment on the prairies. The above control recommendations will likely be effective against these species as well.

The bee louse

The bee louse, *Braula coeca*, is not a true louse but a wingless fly adapted to clinging to the branched hairs of the adult honey bee. The adult louse feeds on pollen and nectar at the bee's mouth. Eggs are laid on the cappings of honey cells, and the larvae tunnel through the cappings as they feed. The bee louse is generally considered harmless to honey bee colonies, but if numerous, they may become a pest by detracting from the appearance of the comb honey cappings. The adult louse bears a superficial resemblance to the varroa mite (Figure 69).

Unwelcome Intruders

Mice

Mice tend to find their way into overwintering colonies and stored hive equipment. If entrances are not blocked or screened, mice will enter hives over winter and will nest in the bottom brood chamber, chewing holes through brood frames in the process of nest-building. Mice also tunnel through the insulation surrounding wintering colonies, often rendering it unusable for the next year. In stored equipment, mice will destroy combs by building nests and chewing on the wax for pollen and dead brood.

Overwintering hive entrances should be blocked down to a small size when winter wraps are put on. Some beekeepers block the lower entrance completely; others leave a small entrance (8 mm²) in the centre, too small for mice to enter. Upper entrances are generally safe from mouse entry owing to their location and small size. Poisoned grain or commercial rodent bait may be placed on inner covers, with the feeder holes blocked, below the insulation and under hives.

If the storage shed is not rodent-proof, the stacks should be, with cracks blocked up and queen excluders or tight-fitting lids above and below each stack. Rodent bait or grain used in the shed should be in flattened tin cans with small openings, so other animals do not come into contact with it.

Skunks

Skunks can be a major problem in apiaries, especially in the spring and fall. Nocturnal by nature, skunks will scratch at hive entrances until bees emerge, then will lap up the bees caught in their fur. Stings do not seem to bother them.

Skunks will switch from hive to hive in an apiary, decimating the adult honey bee population in each hive and angering the colony to a point where it cannot be handled. Skunks also tear and damage winter wrapping material and may even nest in the insulation on top of the hives. Signs of skunk visitation include scratches on hive fronts, matted and torn vegetation, scratches or holes in the ground in front of the entrances and extremely angry and weakened colonies.

As skunks tend to stay in the vicinity and return to the apiary, trapping or shooting are effective means of control. A completely closed box trap is apparently better for keeping the skunk from releasing its scent and may also help retain any odor. Plans for such a trap are available from the apiculture office. Trapped skunks may be gassed, shot or released elsewhere.

A piece of screening extending up and out from the hive entrance will protect the hive and the winter wrap from scratching by skunks. If the skunk tries to climb the screen, its underbelly will be exposed to bee stings. A board with many sharp nails pointed upwards placed on the ground in front of the hive entrance also helps deter skunks from scratching at the hive.

Bears

Beekeeping operations can suffer tremendously from bear depredation in bee yards. Not only do bears eat the bees and brood, they usually destroy and scatter hive equipment and can cause thousands of dollars worth of damage to apiaries.

The extent of bear damage varies from year to year depending on factors like the severity of the previous winter, the reproduction and survival rate of young bears and the availability of territory and natural food sources. Bears have to learn that honey bee colonies are a food source, but once they discover that fact, they tend to return to the apiary or to visit other apiaries.

Bear damage to apiaries can usually be avoided. Putting apiaries in or near preferred bear habitat, such as stream banks and bush, will mean an increased chance of bear problems. Apiaries should be located away from these areas and should be kept clean of broken frames, comb and other attractants.

Using electric fences around apiaries is the most effective means of keeping bears out. Fences must be properly constructed and maintained to be effective, and they must be in place and in operation before a bear problem develops. Once the bear has a taste for brood, a fence may not stop further entry.

Construction should consist of posts 1.25 m tall and 6-8 m apart, with at least 3 wires at heights of 25 cm, 50 cm and 75 cm. Steel telephone wire or electroplastic wire is preferred over barbed wire for ease of handling. A gate wide enough for trucks to pass through should be included. A 12-volt battery, preferably of a type used in recreational vehicles, and a good quality fencer are necessary. Solar fencers are preferable since batteries may run down. The fences or batteries may be located within the fence if problems with two-legged intruders are anticipated.

The fence may be baited with bacon rind or a punctured sardine can so that the first points of contact for the bear are the nose and tongue. Vegetation must be mowed or treated with herbicide in a 50 cm strip under the fence to avoid shorting out the fence.

Detailed information on bear fences may be obtained from the apiculture office or wildlife offices.

If bear damage continues, shooting or trapping and removal are the alternatives. Beekeepers should contact their wildlife division for information and regulations.

The Africanized honey bee

The Africanized honey bee is now present in South, Central and North America. This bee originates from stock of *Apis mellifera scutellata*, a tropical honey bee strain from Africa that was introduced into Brazil in 1956. Since its introduction and escape from managed hives, this strain has migrated in all directions and has largely displaced the previously introduced European strains. This bee has changed the scope of beekeeping in tropical and subtropical areas of the Americas.

The Africanized bee differs from European strains in several ways. It tends to nest in much smaller cavities, and exposed nesting sites are common. It has a high swarming rate and hive abandonment (absconding) often occurs, whereas absconding is rare in European strains. Honey storage characteristics differ: tropical African and Africanized strains tend to store less honey than do European strains. Africanized worker bees are smaller and have a shorter lifespan than European worker bees.

The best known trait of the Africanized bee is its well-developed defensive behavior. Tropical African and Africanized honey bees have a greater tendency to react to colony disturbance. Large numbers of workers will take part in this colony defense and will follow intruders further and attack for a longer period than will European strains. Both human and animal deaths have been attributed to these prolonged attacks.

Researchers feel the Africanized honey bee will not be able to withstand winter conditions throughout most of the United States and Canada. However, the presence of this strain may be disruptive in queen and package-producing areas of the southern U.S. and California. Should stock with strong defensive and swarming tendencies be brought into Canada in packages, its presence here, even during the summer, may cause increased incidences of stinging to non-beekeepers. This stock could also affect honey production.

Pesticide Poisoning of Honey Bees

Because honey bees are insects, they are very susceptible to the toxic effects of insecticides. Pesticides are a necessary and unavoidable aspect of today's agriculture, but the death of honey bee colonies through pesticide poisoning is unnecessary and can usually be avoided. The onus is on the beekeeper to take an active role in protecting his or her colonies from pesticide effects.

Toxicity of pesticides to honey bees

Pesticides enter honey bees most commonly by direct contact, through contact with spray droplets in the air and with sprayed plant surfaces. They may also be taken in orally or through the respiratory system. The pesticides may affect the digestive tract so that the adult bee can no longer nourish itself, or the nervous system so that legs, wings and organ systems no longer function properly. Death may be immediate, in which case bees die in the field, or delayed, so that they die in or near the hive.

House bees and brood may also be affected if pesticides are carried back to the hive. Pesticides may also have sub-lethal effects on the colony, disrupting egg-laying and normal colony functioning and causing chilling or starvation of brood.

The onus is on the
beekeeper to take an
active role in
protecting his or her
colonies from
pesticide effects.

Bee poisoning may occur when crops on which the bees are foraging are sprayed. But poisoning may also occur indirectly, through drift of sprays to adjoining fields or through contamination of flowering weeds such as dandelions and hawk's-beard in the field or orchard. Dichlorvos, the active ingredient on a no-pest strip, has a high affinity for wax and will be absorbed into exposed beeswax combs, subsequently being released in lethal doses and killing both adult bees and brood. Vapona strips should never be used in honey houses or sheds where combs are stored.

The pesticide formulation is a major factor affecting both its immediate and residual toxicity to honey bees. Any formulation that increases the amount of pesticide the honey bees come into contact with will generally increase its toxicity. Thus, dusts and sprays of wettable powders are often more toxic than sprays of liquid formulations such as emulsifiable concentrates. Coarse sprays are more toxic than fine sprays, and granular formulations are usually very low in toxicity because the toxic compound is not available for direct contact.

Incorrect dosage and application times may greatly increase toxicity and hazard to honey bees. Many pesticides are not harmful to honey bees if applied in the correct formulation, at the correct rate and at the correct time of day. These pesticides may be highly toxic, but they have a short residual effect, breaking down to a safe level soon after application. Thus, if they are applied at dusk after the bees have stopped foraging, or in some cases in the early morning before foraging begins, there is no longer any toxic effect by the time the bees reach the field.

Some pesticides and formulations are extremely toxic to honey bees and must not be applied to flowering crops or weeds at all, while some are relatively non-toxic to honey bees and may be applied during flowering, but never while bees are foraging. Residual toxicity of a pesticide may also be affected by temperature.

Symptoms of bee poisoning

Symptoms of bee poisoning vary depending on the type of pesticide used. Large numbers of dead bees in front of the hives is a typical sign, as is severe dwindling of the adult population. Dying bees may appear paralyzed, stupefied and unable to fly or walk without tumbling. Bees may regurgitate the nectar, causing them to look wet; their abdomens may be swollen, and the bees may be very aggressive. Abnormal brood patterns may be seen, or the queen may stop egg laying altogether, and house bees may begin superseding cells. Chilled and dead brood may be seen in combs or in front of the hive. Colonies may be completely dead, or the population may be knocked back enough that honey production will be reduced.

See Table 12 for pest problems that have the potential to affect beekeeping operations through spray programs.

Table 12. Some pest problems with potential affects on honey bees through direct spraying of bees and/or colonies or through spray drift to flowers in adjacent fields and along roadsides.

Insect	Time of Year (stage of crop)	Plant Species	Recommended Treatment (1997)*
Forest Tent Caterpillar	May, June	Shelterbelts and bush	Dipel, Thuricide ⁴ Dylox 420 ³ Methoxychlor EC ³ Malathion 50 EC ² Sevin XLR ² Diazinon EC ¹ Sevin WP ¹
Flea Beetles	late May - mid-June (seedling)	Canola Mustard	IN-FURROW OR SEED Lindane ⁴ Furadan 5G ⁴ Counter 5G ⁴ FOLIAR SPRAYS Decis 5.0 EC ² Malathion 500 EC ² Supracide 25 EC ¹ Furadan 480 F ¹ Sevin liq. susp. ¹ Guthion 240 SC ¹
Clover Cutworms	late May - mid-June (seedling) July (bloom)	Canola, Flax, Canola, Alfalfa	Lorsban 4E ¹ Decis 5.0 EC ²
Sweet Clover Weevil	late May - mid-June (seedling) Fall	Sweet Clover	Sevin XLR ² Malathion 500 EC ² Cygon 480 EC ¹ Guthion 240 SC ¹ Sevin liq. susp. ¹
Lygus and Alfalfa Plant Bugs	late June (pre bloom) late July (bloom)	Alfalfa (seed)	Dylox 420 L ³ Decis 5.0 EC ² Supracide 25 EC ¹ Cygon 480 EC ¹
Alfalfa Weevil	mid-June (pre bloom) mid Summer (bloom)	Alfalfa (seed)	Malathion 500 EC ² Guthion 240 SC ¹
Alfalfa Looper	late June, July (pre bloom, bloom)	Alfalfa (seed)	Lorsban 4E ¹

Table 12. (continued)

Insect	Time of Year (stage of crop)	Plant Species	Recommended Treatment (1997)*
Grasshoppers	all summer	All Crops Pastures	ALL CROPS Hopper Stopper ⁴ Sevin XLR ² Malathion 500 EC ² OILSEEDS Monitor 480 L CEREALS Decis 5.0 EC ² Guthion 240 SC ¹ Sevin liq. susp. ¹ Cygon 480 EC ¹ Hopper Spray 400 EC ¹ FORAGES Guthion 240 SC ¹ Cygon 480 EC ¹ Supracide 25 EC ¹
Wheat Midge	late July, early August	Wheat, Barley	Lorsban 4E ¹ Cygon 480 EC ¹
Diamondback Moth	late July, August (bloom, post bloom)	Mustard Canola	Dylox 420 EC ³ Malathion 500 EC ² Guthion 240 SC ¹ Supracide 25 EC ¹ Decis 5.0 EC ²
Bertha Armyworm	mid-August (bloom, post bloom)	Canola Flax	Lorsban 4E ¹ Monitor 480 L ¹ Lannate L ¹ Decis 5.0 EC ²
Aphids	August	Forage Crops	ALL CROPS Cygon 480 EC ¹ Sys Tern 480 EC ¹ CEREALS Systox 240 SC ³ FORAGES Malathion 500 EC ² Supracide 25 EC ¹
Ants	Beekeeping season in bee hives		Diazinon 2% dust under back of hives (MUST NOT contact bees or comb)

Table 12. (continued)

Insect	Time of Year (stage of crop)	Plant Species	Recommended Treatment (1997)*
Flies, Honey Bees, Wasps	July, August in honey house		Bee-tight building Bee escapes in windows Flyswatters DO NOT USE VAPONA
Wax Moths	Year-round in stored supers		Store in sub-zero temperatures Paradichlorobenzene crystals between supers Bacillus thuringiensis (Certan) ⁴ DO NOT USE VAPONA

* Recommendations from Saskatchewan Agriculture's *Crop Protection Guide (1997)*. Additional guidelines can be found in Alberta Agriculture's *Crop Protection with Chemicals 1998*, Agdex 606-1. Toxicity ratings from Carl Johansen, Entomologist Washington State University, Pullman, Washington.

- ¹ Highly toxic to honey bees. Do not apply to crops or weeds in bloom.
- ² Apply only during late evening.
- ³ Apply only during late evening, night or early morning.
- ⁴ Can be applied at any time with reasonable safety to bees.

Preventing losses

Most growers and spray applicators do not want to kill honey bees. But if a crop is threatened by a pest outbreak, the grower is going to spray, bees or no bees. It is up to the beekeeper to protect colonies from being severely set back or destroyed.

Here are several approaches that should allow for insecticide use with a minimum of risk to bees:

- Initiate and maintain contact with the farmers and commercial pesticide applicators in your area and let them know where your colonies are located. Clearly post your name, address and telephone number at each apiary location so that you can be easily contacted by local farmers and pesticide applicators.
- Become familiar with the common insect pests in your area and when spray programs take place, so you will be aware of the problems facing the grower and when the bees may be threatened (Table 12).
- Pesticide applicators should be encouraged to use the pesticides that are least toxic to bees.
- Restricting the application of many insecticides to the late evening or very early morning, when bees are not foraging, lessens the possibility of causing injury to honey bees and other pollinating insects.
- Insecticides should not be applied to crops in bloom. Today, it is so common for bees to be kept in the prairie provinces that almost every blooming field is likely to have honey bees actively foraging in the area.

- Should spraying be imminent and the movement of colonies impractical, bees may be confined to the hive for a few hours to minimize contact with the pesticide. However, care must be taken to prevent overheating of the colony during periods of confinement.

Screened colonies can be assisted with cooling by supplying water-filled combs and by covering the hive with wet burlap and keeping it wet. During warm days, strong colonies should not be confined for more than a few hours. The length of confinement will depend on the residual toxicity of the pesticide in use.

Documenting bee kills

Pesticide kills should be reported to the apiculture office, even if litigation is not intended. These reports, if clearly documented, are very useful in determining both the severity of the pesticide poisoning situation and the ways to avoid similar situations in the future.

The documentation of pesticide kills is necessary, especially if the beekeeper intends to pursue compensation for losses. Watch for symptoms of dying bees, and if a number of bees are dead, collect several handfuls of them and freeze them immediately. When transported, the bees should be kept frozen with dry ice, as pesticide residues break down quickly at warm temperatures.

If litigation is intended, an impartial witness should be present when samples are collected. Photographs of the affected apiary will be useful. Records must be kept of the date and time of day of pesticide spraying, weather conditions both at the time and two days before and after, the pest target, the crop, the pesticide, its formulation and rate of application and the distance of the apiary from the sprayed fields.

It will be difficult for the beekeeper to win a court case unless the apiary is sprayed directly or affected by spray drift, or the bees are foraging on land owned by the beekeeper that is mistakenly sprayed or affected by spray drift. However, the beekeeper should report the applicator to provincial licensing authorities under the following conditions:

- if the aerial applicator is spraying a field during daylight hours with a pesticide labeled clearly only for application before dawn or after dusk, or
- using a pesticide or formulation not registered for use on the crop in question and does not have a special permit.

Reporting the applicator is a dramatic measure, and hopefully, previous communications between all concerned parties will have resolved any potentially hazardous spraying situation. The beekeeper must still depend on the local growers for apiary sites and bee forage, even though many growers would see much lower returns without the pollinating bees. Early and continued communication between beekeeper and grower will be much more effective in preventing bee losses and maintaining good will than action after the fact.

Appendix A

Glossary of Apiculture Terms

Abdomen – Segmented posterior part of bee containing heart, honey stomach, intestines, reproductive organs and sting.

***Acarapis woodi* (Rennie)** – Scientific name of honey bee tracheal mite, which infests tracheae of bees.

Acarine disease – A malady of adult bees caused by a mite, *Acarapis woodi*, infesting the thoracic tracheae.

Acid board – See fume board.

African bee – See *Apis mellifera scutellata*.

After-swarms – Swarms that may leave the hive after the first or prime swarm has departed.

Alarm odour – A chemical substance released from the vicinity of a worker bee's sting that alerts other bees to danger. Isopentyl acetate is the principal alarm odour; 2-heptanone, found in worker bee mandibular glands, is a secondary alarm odour.

Alighting board – Extended entrance to beehive on which incoming bees land.

American foulbrood (AFB) – Contagious disease of bee larvae caused by *Bacillus larvae* White (also known as *Paenibacillus larvae* var. *larvae*).

Antennae – Slender jointed feelers, which bear certain sense organs, on heads of insects.

Anther – Part of flower that develops and contains pollen.

Apiarist – Beekeeper.

Apiary – The location and sum total of colonies, hives and other equipment assembled in one site for beekeeping operations.

Apiculture – The science and art of raising honey bees for economic benefit or personal enjoyment.

Apis – Genus to which honey bees belong.

Apis adeniformis – Similar to *A. florea*; found in southeast Asia.

Apis cerana – This species is found throughout Asia, and in certain countries, it is the honey bee of commerce.

Apis dorsata – Scientific name for giant bee of Asia; largest of all honey bees.

Apis florea – Being the smallest of the four species of honey bees, it is often called the dwarf bee. This species is native to Asia only, though it is more western in distribution than the other Asian species (*A. florea* has recently been inadvertently introduced into Africa).

Apis laboriosa – Similar to *A. dorsata*; found in limited high altitude areas of Asia.

Apis koschevnikovi – Similar to *A. cerana*; found in southeast Asia.

Apis mellifera – The common honey bee found throughout the western world though originally from the near-east. Humans have carried *Apis mellifera* from Europe to all continents.

Apis mellifera scutellata – The African bee. This is a race of *Apis mellifera* that has become established and spread throughout south and central America and recently found in the southern USA.

Apis nigrocincta – Similar to *A. cerana*; found in Suluwezi.

Apis nuluensis – Similar to *A. cerana*; found in Borneo.

Artificial insemination – See instrumental insemination.

***Bacillus larvae* White (*Paenibacillus larvae* var. *larvae*)** – Bacterial organism causing American foulbrood.

Ballng a queen – An attack on a queen by a number of worker bees intent on killing her by pulling at her legs and wings, stinging and suffocation. In this process, the bees form a small cluster or tight ball of bees around the queen.

Bee blower – A blower driven with a gasoline engine used to remove bees from full supers of honey.

Bee bread – Stored pollen in comb.

Bee brush – A brush or whisk broom used for removing bees from combs.

Bee dance – Movement of bee on comb as means of communication, usually same movement is repeated over and over.

Bee escape – Device to let bees pass in only one direction, usually inserted between supers of honey and brood nest when removal of bees from honey is desired.

Bee glue – See propolis.

Bee gloves – Long gloves made of cloth or leather to protect the hands and wrists from stings.

Bee gum – A hollow log used for housing a colony of bees.

Beehive – Domicile for colony of honey bees.

Bee house – A house constructed to maintain colonies of bees, usually in rows along the side with openings to the outside.

Beekeeper, commercial – A beekeeper managing 200 or more hives as a main or sole source of livelihood. Honey crop generally sold in bulk. Operations of over 400 hives generally require additional help.

Beekeeper, hobby – A beekeeper tending up to 50 hives, generally to fulfill an interest and to have some honey to sell privately.

Beekeeper, sideline – A beekeeper tending 50-200 hives, generally to fulfill an interest and to supplement income.

Bee louse – Relatively harmless wingless fly found in colonies. Larvae can damage honeycomb. Scientific name is *Braula coeca* Nitzsch.

Bee paralysis – Condition of adult bees, caused by a virus that prevents them from flying or performing other functions normally.

Bee plants – Plant species visited by bees for nectar and/or pollen.

Bee space – The natural space found between combs built by bees. This space is big enough to permit free passage of bees. It measures 5 to 9 mm. Spaces larger than a bee space will be filled with burr comb or full honey comb. Spaces less than a bee space will be sealed with propolis. Langstroth applied this observation to North American hive equipment construction.

Beeswax – A complex mixture of organic compounds secreted by four pairs of glands on the underside of the worker bee's abdomen and used by bees for building comb. Its melting point is from 62°C-64°C (143.6°F to 147.2°F).

Bee tree – A hollow tree occupied by a colony of bees.

Bee veil – Screen or net worn over head and neck for protection from bee stings.



Bee venom – Poison injected through bee sting.

Bee yard – See apiary.

Beeway section – Comb honey sections with a built-in beeway or bee space.

Bottom board – Floor of beehive.

Brace comb – Small pieces of comb made as connecting links between combs or between a comb and the hive itself. See burr comb.

Braula coeca – The scientific name of a wingless fly known as bee louse. It is of little economic importance. See bee louse.

Breathing pores – See spiracles.

Brood – Immature or developing stages of bees: includes eggs, larvae and pupae.

Brood chamber – The part of a hive where the brood is reared and food is stored. May include one or more hive bodies and the combs within.

Brood comb – Wax comb from brood chamber of hive containing brood. Usually a dark color.

Brood food – Secretion of highly nutritious food, used to feed young larvae and queens, produced in the hypopharyngeal glands in the heads of adult bees.

Brood nest – Area of hive where bees are densely clustered and brood is reared.

Brood rearing – The raising of young bees from eggs to larvae to pupae to young adult stage.

Build-up – The natural increase in population of honey bees within a colony, reaching peak population at the commencement of the main nectar flow.

Bulk comb honey – Comb honey produced in shallow frames and usually sold as a complete unit in the frame. See chunk comb honey.

Burr comb – Comb built out from wood frame or comb, but usually unattached on one end because the space exceeds “bee space.”

Candy – See queen cage candy.

Cap – Covering of cell.

Capped brood – Brood whose cells have been sealed by the bees with a porous cover to isolate the immature bees within, during their nonfeeding pre-pupal and pupal periods.

Capped honey – Honey stored in sealed cells.

Cappings melter – Various types of melters used to liquefy the wax from cappings.

Cappings – The thin wax covering of cells full of honey. Same term used for material sliced from the surface of a honey-filled comb before extracting the honey.

Carniolan bee – *Apis mellifera carnica*. Gentle greyish-black bee originally from southern Austria, northern Yugoslavia and the Danube Valley.

Castes – The three forms of bees: workers, drones and queen.

Caucasian bee – *Apis mellifera caucasica*. Dark bee originating in the Caucasus mountains, noted for its heavy propolizing characteristic.

Cell – Single unit of space in comb in which honey is stored or a bee can be raised; worker cells are about 4 cells per square cm (25 cells per square inch) of comb, drone cells are about 2 1/2 cells per square cm (18 per square inch).

Cell cup – An artificial queen cell base made of beeswax for rearing queen bees.

Chilled brood – Immature bees that have died from being too cold, frequently because of mismanagement.

Chunk comb honey – Type of honey pack in which a piece of honey comb is placed in container of liquified honey or wrapped “dry” in plastic container.

Clarified honey – Honey that has been heated, then filtered to remove all wax or other particles.

Cleansing flight – Flight bees take after confinement, during which they would void their feces outside the hive.

Clipped queen – Queen whose wing (or wings) has been clipped for identification purposes or swarm control.

Cluster – The form or arrangement of bees within a hive when ambient temperature drops below 14°C (57°F).

Colony – An aggregate of several thousand worker bees, drones and a queen bee living together in a hive or in any other dwelling as one social unit.

Comb – A back-to-back arrangement of two series of hexagonal wax cells that hold eggs, brood, pollen or honey.

Comb foundation – Manufactured sheets of beeswax with the foundation of worker cells embossed into the wax.

Comb honey – Honey in the comb usually produced in small wooden or plastic sections.

Compound eyes – The two large lateral eyes of the adult honey bee composed of many visual elements called ommatidia.

Cross-pollination – Transfer of pollen from anther of one plant to stigma of different plant of same species.

Cyanogas – A commercial preparation of calcium cyanide used to kill bees that are diseased or a nuisance in buildings and other undesirable places. It forms hydrogen cyanide gas on contact with moist atmosphere. It is a very poisonous material and must be handled with care. The gas is lighter than air.

Deep super – A super used to hold standard, full-depth frames; the usual depth is 241 mm or 244 mm (9 1/2" or 9 5/8").

Demaree – The beekeeper who invented a popular method of swarm control, also used as a verb, “to demaree,” in describing this method. It consists of separating the queen from most of the brood.

Dextrose – Also known as glucose, one of the principal sugars of honey. Also found in nectar.

Diastase – Enzyme that aids in converting starch to sugar. The diastase level is used as an index of the heating history of a honey.

Dividing – Separating a colony to form two or more new colonies.

Division board – A thin vertical board of the same length and height as the inside of a super. It is used to reduce the size of the chamber or to vertically divide the hive into two parts.

Division board feeder – A wooden or plastic compartment or trough hung in a hive in place of a frame and used for feeding sugar syrup to bees.

Drawn combs – Combs having the cells built out by honey bees from a sheet of beeswax or plastic foundation.

Drifting – The tendency of bees to transfer to colonies other than their own because of a lack of visual cues to orient them to their “home” hive.

Drone – Male bee.

Drone brood – The male brood that is reared in larger cells than worker brood.

Drone comb – Wax comb with about 2 1/2 cells per square cm (18 per square inch). Combs with a high proportion of drone cells are not recommended in the brood chamber.



Drone-layer – A queen that lays only unfertilized eggs, which result in drones, because she no longer has any sperm, was poorly mated or was not mated at all.

Dwindling – Rapid or unusual depletion of hive population.

Dyce process – A patented process involving pasteurization and controlled granulation to produce a finely granulated honey product that spreads easily at room temperature.

Dysentery – A condition of adult bees resulting from an accumulation of feces within the gut. It usually occurs during winter and is caused by unfavorable wintering conditions and poor quality food. Dysentery is detected by fecal spotting around the entrance and within the hive. Often associated with nosema disease.

Embed – To force wire into comb foundation by heat, pressure or both for the purpose of strengthening the comb.

Emerging brood – Young adult bees first coming out of their cells.

Entrance blocks – Pieces of wood used in regulating the size of hive entrances.

Escape board – A board having one or more bee escapes in it and used to remove bees from supers above the bee escape.

European foulbrood – A brood disease of bees caused by *Melissococcus (Streptococcus) pluton*.

Excluder – See queen excluder.

Extractor – A machine that rotates honeycombs at sufficient speed to remove honey from the cells by centrifugal force.

Feces – Excreta of bees.

Fermentation – A chemical breakdown of sugar caused by yeasts; in honey, fermentation is caused by the genus *Zygosaccharomyces*.

Fertile queen – A queen that has been inseminated artificially or naturally with drone spermatozoa and is capable of laying fertilized eggs.

Field bees – Worker bees that are usually 21 or more days old and work in the field to collect nectar, pollen, water and propolis.

Flash heater – Device for heating and cooling the honey within a few minutes.

Foundation – See comb foundation.

Frame – Four assembled pieces of wood designed to hold comb. It consists of one top bar, one bottom bar and two end bars.

Fructose – A simple sugar, usually the predominant one in honey. Also found in nectar. (See levulose).

Fume board – A board the length and width of a super with a 3-4 cm rim and a lining of absorbent cloth, on which is placed one of several bee repellents. The fume board is then placed on the bee hive, and the bee repellent drives the bees out of the honey super.

Fumidil-B – A trade name for fumagillin, the antibiotic for controlling nosema disease.

Galleria mellonella (L.) – Scientific name of greater wax moth.

Glucose – See dextrose.

Grafting – A process of removing a worker larva from its cell and transferring it to an artificial queen cup to have it reared into a queen by bees.

Granulated honey – Crystallized honey.

Green honey – Unripe honey.

Hive – Human-constructed home for bees.

Hive body – A wooden box that encloses the frames.

Hive stand – A structure that supports the hive.

Hive tool – A metal device used to open hives, pry frames apart, clean the hive, etc.

Hoffman frame – Frames with end bars widened at the top to act as a spacing device.

Honey bee – The common name for *Apis mellifera*. Order Hymenoptera, Family Apidae.

Honeydew – Sweet secretions from aphids and scale insects.

Honey flow – See nectar flow.

Honey gate – A faucet used for removing honey from tanks.

Honey house – A building used for extracting honey packaging honey, storing supers, etc.

Honey pump – Pump for transferring honey from one container to another.

Honey stomach (honey sac) – The part of the bee's digestive tract (crop) adapted to carrying nectar, honey or water, located in the front part of the abdomen.

Honey sump – See sump.

Hormone – Substance produced in small quantity in one part of body (usually in gland of internal secretion) and transported to other parts, where it exerts its action.

Hymenoptera – An order of insects to which all bees belong, as well as ants, wasps and sawflies.

Inner cover – A lightweight cover used under a standard telescoping cover on a bee hive.

Instrumental insemination – The introduction of drone spermatozoa into the genital organs of a virgin queen by means of special instruments.

Invertase – An enzyme produced by honey bees that speeds inversion of sucrose to glucose and fructose.

Isle of Wight disease – An early and little used name for acarine disease.

Italian bees – *Apis mellifera ligustica*. Bees originating from Italy, most common race in North America.

Langstroth frame – A frame measuring 48 cm long (top bar) by 23 cm deep (19" x 9 1/8").

Langstroth hive – Hive with movable frames. Dimensions such that the bee space is allowed between surfaces.

Larva – The second stage in the complete development of an insect, such as the honey bee, having complete metamorphosis or four stages – egg, larva, pupa, adult. The plural of the term is larvae.

Laying worker – A worker bee that lays eggs that develop into drones. Laying workers usually develop in colonies that have been queenless for a long period.

Legume – One of the family Leguminosae, which includes clover, alfalfa, peas and beans.

Levulose – Fructose or fruit sugar, one of the major sugars, with glucose, of honey.

Mandibles – The jaws of an insect. In the honey bee and most insects, the mandibles move in a horizontal rather than in a vertical plane.

Manipulation of colonies – Using hive equipment to best advantage in aiding colony development.

Mating flight – The flight taken by a virgin queen during which time she mates in the air with one or more drones. Normally queens mate six to eight times during one or more mating flights.

Mead – Wine made from honey.

Metamorphosis – Changes of insect from egg to adult.



Migratory beekeeping – The moving of colonies of bees from one locality to another during a single season, for pollination or to take advantage of two or more nectar flows or different crops.

Movable frame – A frame or comb constructed on the principle of the “bee space.” When placed in a hive, it remains unattached to its surroundings (by pieces of burr comb or heavy deposits of propolis) and is, therefore, easily removed.

Nectar – A sweet carbohydrate secretion by glands or nectaries in different parts of plants, chiefly in the flowers. The raw source of honey. See nectaries. See sucrose.

Nectaries – Plant glands that secrete nectar.

Nectar flow – The time of year when the production of nectar by various plant species is great enough that bees gather and store the nectar and convert it to honey.

No Ceema Fix – A trade name for fumagillin, used to control nosema disease.

Nosema disease – Disease of adult bees caused by protozoan spore-forming mid-gut parasite, *Nosema apis* Zander.

Nucleus – A small colony of bees often used in queen rearing, or mating or increasing colony numbers.

Nurse bees – Young worker bees that feed larvae.

Observation hive – A hive, usually only large enough for one frame, made with clear sides to permit observation of the bees at work.

Ocellus – A simple eye with a single lens. The honey bee has three ocelli on the top of its head.

Ommatidium – One of the visual units comprising the compound eye.

Out apiary – An apiary kept at a distance from the home or honey house of the beekeeper.

Overstocking – A condition reached when there are too many colonies of bees for a given locality.

Package bees – Two or three pounds of bees that are shaken from combs of beehives into wire mesh cages for transportation and sale. Into each package is placed a caged, mated queen.

Paralysis – See bee paralysis.

Parthenogenesis – The development of young from unfertilized eggs. In honey bees, the unfertilized eggs produce only drones.

Pfund grader – A device used to give a numerical value to honey color.

Pheromone – A chemical secretion released externally by one animal that stimulates a response in a second animal of the same species.

Piping – A series of sounds made by queens.

Pistil – Female part of flower consisting of stigma, style and ovary.

Play flights – Short orientation flights taken by young bees in front of the hive and in its vicinity to acquaint the young bees with their immediate surroundings. These are sometimes mistaken for robbing or preparation for swarming because they may involve large numbers of bees at one time, usually mid-afternoon.

Pollen – The male sex cells of plants gathered by worker bees from the anthers of flowers. Pollen provides protein, minerals, fats and vitamins that are consumed by the young nurse bees and elaborated into brood food or “royal jelly.”

Pollen basket (corbiculum) – A flattened concave depression surrounded by curved spines, located on the outside of the tibiae of the bee’s hind legs and adapted for carrying the pollen gathered from flowers to the hive. The mass of pollen within each corbiculum is referred to as a pollen pellet.

Pollen insert – A pollination device inserted into the entrance of a colony into which hand-collected pollen is placed. As the bees leave the hive and pass through the trap, some of the pollen adheres to their bodies and is carried to the blossoms, resulting in cross-pollination.

Pollen substitute – A food material used to substitute wholly for pollen to supply the needed protein, vitamins and fats to a bee's diet. It includes water, sugar and other materials such as soy flour and/or brewer's yeast.

Pollen supplement – A mixture of pollen and other protein sources (as above) along with sugar and water, fed to colonies to supplement their protein needs.

Pollen trap – Device installed over colony entrance that scrapes and accumulates pollen from the pollen baskets on the hind legs of bees returning to their hives.

Pollination – The transfer of pollen from the anthers (male) to the stigma (female) of flowers.

Prime swarm – The first swarm to issue, usually with the old queen, from the parent colony.

Proboscis – Tongue of bees and other insects.

Propolis – Resins and gums gathered from trees and used by bees in sealing cracks, repairing cells and covering objectionable material within the hive. Also referred to as bee glue.

Pupa – Third stage in the development of an insect having complete metamorphosis. In this stage, the organs of the larva are transformed into those that will be used as an adult. See larva.

Queen – Sexually developed female bee, larger and longer than worker bee.

Queen banks – Colonies in which caged queens are placed for storage until use.

Queen cage – A small cage in which a queen and five or six worker bees may be confined for shipping and/or introduction into a colony. May or may not contain candy.

Queen cage candy – Candy made by kneading powdered sugar with invert sugar syrup until it forms a stiff dough, used in queen cages.

Queen cell – A special elongated cell resembling a peanut shell in which the queen is reared. It is usually an inch or more in length. The inside diameter is about 8 mm. It hangs down from the comb in a vertical position.

Queen cup – A cup-shaped cell that hangs vertically in a hive. It is made of beeswax or plastic and may become a queen cell if an egg is placed in it and if bees add wax to it. See queen cell.

Queen excluder – A device made of wire, or wood and wire or zinc, having openings of about 5 mm that permit workers to pass through but exclude queen and drones. It is used to confine the queen to a specific part of the hive, usually the brood chamber.

Queenless – Without a queen.

Queen mailing cages – Cages 8 x 3 x 2 cm in which a mated queen with 6 to 10 attendant workers and a soft candy for food are placed for the purpose of travel through the mail.

Queen mating nuclei – Small colonies in which unhatched queen cells are placed and from which virgin queens will make mating flights.

Queen-rearing colonies – Colonies managed in such a way as to produce queen cells.

Queen-right – With a queen.



Queen substance – Queen mandibular pheromone produced from glands in head of queen, has strong effect on colony behavior and the sexual development of worker bees and is also a sex attractant during queen mating flights.

Rendering wax – The process of melting combs and cappings and refining the wax.

Ripe honey – Honey from which bees have evaporated sufficient moisture so that it contains no more than 17.8 per cent water.

Robbing bees – Bees that enter colonies other than their own to remove honey and carry it to their own hive. Usually occurs in early spring and fall.

Robbing – Term applied to bees stealing honey from other colonies, cappings, recently extracted honey supers, etc.

Royal jelly – A highly nutritious glandular secretion of young adult worker bees; it is used to feed the queen and the young brood.

Sacbrood – A viral disease of honey bee larvae causing death of the larvae.

Sealed brood – Brood in late larval and pupal stages with cells sealed. See capped brood.

Self-spacing frames – Frames made with a spacing device so that when they are pushed together they stand a bee space apart. See Hoffman frame.

Self-pollination – Transfer of pollen to stigma within the same flower or to a different flower of the same plant.

Septicemia – Usually minor disease of adult bees caused by *Pseudomonas apiseptica* (Burnside).

Scent gland – Nasanov gland of worker honey bees located dorsally between sixth and seventh segments of abdomen.

Sex attractant – A chemical substance that attracts an animal of the same species, male or female, for the purpose of mating. The sex attractant in *Apis mellifera* is 9-keto-(E)-2-decenoic acid.

Shaking – The process of placing bees from parent colonies into packages or vice versa.

Shallow super – Any one of several super depth sizes less than the depth of a standard super. Commonly, shallow supers vary from 11 to 18 cm (4-7") in depth.

Skep – A basket made of coiled straw or wicker, once used in the inverted position as a domicile for honey bees. Since individual combs are not readily movable for disease inspection, their use is illegal in North America.

Slumgum – The refuse from melted comb and cappings after the wax has been rendered or removed.

Smoker – Device used to produce and blow smoke on bees to help in calming them.

Solar wax extractor – Glass-covered box in which wax combs are melted by sun's rays, and the beeswax is recovered.

Spermatheca – A small organ connected with the vagina of the queen in which the spermatozoa received in mating with drones are stored.

Spiracles – Openings in the body wall through which the bee breathes: external openings of tracheae.

Stamen – Male part of flower on which pollen-producing anthers are borne.

Stigma – Receptive part of pistil where pollen germinates.

Sting – Modified ovipositor of female Hymenoptera developed into organ of defense.

Sucrose – Cane sugar: also the major sugar in nectar.

Sump – Temporary holding area for honey between extractor and tank.

Supers – A hive box or hive bodies with or without frames.

Supersedure – Replacement of the existing queen by a young queen produced by the bees within the colony from their own larvae or eggs.

Surplus honey – The honey removed from the hive that is over and above that which bees need for their own use.

Swarm – The aggregate of worker bees, drones and a queen that leaves the mother colony to establish a new colony. Swarming is the natural reproduction and dispersal of honey bee colonies.

Terramycin – A trade name for oxytetracycline, a drug commonly used to prevent European and American foulbrood.

Thorax – The middle region of the bee's body that carries the wings and legs.

Tracheae – The breathing tubes within an insect opening externally via the spiracles.

Tropilaelaps clareae – One of few parasitic mites associated with honey bees. So far known only in Asia.

Uncapping – The process of removing the wax cappings from cells containing honey.

Uncapping knife – A knife used to shave or remove the beeswax cappings or honey cell caps from combs of sealed honey preparatory to extraction. The knives are usually heated by steam or electricity.

Unite – Combine one colony with another.

Unsealed brood – Brood in egg and larval stages only.

Varroa jacobsoni – One of four parasitic mites associated with honey bees. Has been spread from Asia to Europe, North, Central and South America and has become a serious pest of *Apis mellifera*.

Ventriculus – The stomach of the bee located in the abdomen between the honey stomach and the small intestine.

Virgin queen – Unmated queen.

Wax glands – The eight glands that secrete beeswax. They are located in pairs on the last four visible ventral abdominal segments.

Wax moth – Lepidopterous insect (moth) whose larvae destroy wax combs.

Wax press – An appliance used in rendering beeswax.

Wild bees – Solitary or sub-social bees other than honey bees of the genus *Apis*. The term is sometimes used to refer to a nest of honey bees in a tree or wall of a building.

Windbreaks – Specially constructed fences or natural barriers to reduce the force of the wind in an apiary.

Wired foundation – Foundation with strengthening wires embedded in it.

Wired frames – Frames with wires holding sheets of foundation in place.

Worker bee – A female bee whose organs of reproduction are only partially developed and that is responsible for carrying on all the routine work of the colony.

Worker comb – Honeycomb with about 4 cells/cm² (25 cells per square inch).

Appendix B

Additional References

Books

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- American Bee Journal.* Dadant and Sons, Hamilton, ILL. 62341.
- Bee Culture.* A.I. Root Co., Box 706. Medina, Ohio. 44258-0706.
- Bee World.* International Bee Research Association, 18 North Road, Cardiff, England, CF1 3DY.
- Speedy Bee.* Box 998, Jesup Georgia 31545.

Pamphlets

- Pamphlets pertaining to various aspects of beekeeping are available from the provincial apiculture office.
- Honey bee Diseases & Pests.* Canadian Association of Professional Apiculturists
- A Guide to: Managing Bees for Crop Pollination.* Canadian Association of Professional Apiculturists

Appendix C

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Appendix D

Canada Honey Grading Regulations

Here are excerpts from the Canada Agricultural Products Act, Honey Regulations, pertaining to grading honey.

Section 8

Honey may be classified as to colour and graded under these Regulations only if

- (a) it is the food derived from the nectar of blossoms or from secretions of or on the living parts of plants by the work of honey bees;
- (b) it has a consistency that is fluid, viscous or partly or wholly crystallized;
- (c) its composition meets the requirements set out in Table IV of Schedule 1 for a kind of honey specified therein;
- (d) it has
 - (i) a diastase activity, determined after processing and blending, as represented by a diastase figure on the Gothe scale of not less than 8 where the hydroxymethylfural content is not more than 40 mg/kg. or
 - (ii) a diastase activity, determined after processing and blending, as represented by a diastase figure on the Gothe scale of not less than 3 where the hydroxymethylfural content is not more than 15 mg/kg;
- (e) it is clean, wholesome and fit for human consumption; and
- (f) it has not, in the opinion of the Minister, any deterioration seriously affecting its edibility, appearance or shipping quality.

Table III

Grades of Honey

1. "Canada No. 1" is the grade name of honey that, in addition to meeting the requirements as set out in section 8,
 - (a) contains not more than 17.8 per cent moisture or, where its container is marked "pasteurized" or "pasteurisé," not more than 18.6 percent moisture;
 - (b) is free from any foreign material that would be retained on a U.S. National Bureau of Standards standard 80-mesh screen;
 - (c) contains not more than 0.1 percent water insoluble solids or, where its container is marked "pressed" or "de presse," not more than 0.5 percent water insoluble solids;
 - (d) has a flavour characteristic of its colour classification and is free from any objectionable flavour, aroma or taint;
 - (e) where its container is marked "liquid" or "liquide," is clear, bright, uniform in colour and free from visible crystals; and
 - (f) where its container is marked "creamed" or "en crème" or is otherwise marked to indicate that the contents are granulated, has a smooth fine texture and complete and uniform granulation.

2. "Canada No. 2" is the grade name of honey that, in addition to meeting the requirements set out in section 8,
 - (a) contains not more than 18.6 percent moisture or, where its container is marked "pasteurized" or "pasteurisé," not more than 20 percent moisture;
 - (b) is free from any foreign material that would be retained on a U.S. National Bureau of Standards standard 60-mesh screen;
 - (c) contains not more than 0.1 percent water insoluble solids or, where its container is marked "pressed" or "de presse", not more than 0.5 percent water insoluble solids;
 - (d) has a flavour that may be slightly off but its honey flavour is not substantially impaired;
 - (e) where its container is marked "liquid" or "liquide," has a colour that may be dull and cloudy or turbid or slightly uneven and shows not more than slight signs of crystalization in the form of a light suspension or minor sedimentation of crystals; and
 - (f) where its container is marked "creamed" or "en crème" or is otherwise marked to indicate that the contents are granulated, has a texture that may be medium coarse or gritty, but not extremely coarse or gritty, and has a complete and fairly uniform granulation.
3. "Canada No. 3" is the grade name of honey that, in addition to meeting the requirements set out in section 8,
 - (a) contains not more than 20 percent moisture;
 - (b) contains not more than 0.1 percent water insoluble solids or, where its container is marked "pressed" or "de presse," not more than 0.5 per cent water insoluble solids; and
 - (c) has a flavour that may be slightly off but its honey flavour is not substantially impaired.

Schedule 1

(ss. 2, 5, 6, 8, 35 and 36)

Table 1. Prepackaged Honey

Class	Designation on Honey Classifier	"Reading on Pfund Honey Grader"
1. "White"	not darker than White	not more than 30 millimetres
2. "Golden"	darker than White but not darker than Golden	more than 30 millimetres but not more than 50 millimetres
3. "Amber"	darker than Golden but not darker than Amber	more than 50 millimetres but not more than 85 millimetres
4. "Dark"	darker than Amber	more than 85 millimetres



Table II. Honey Packed in Bulk Containers

Class	Designation on Honey Classifier	"Reading on Pfund Honey Grader"
1. "Extra White"	not darker than Extra White	not more than 13 millimetres
2. "White"	darker than Extra White but not darker than White	more than 13 millimetres but not more than 30 millimetres
3. "Golden"	darker than White but not darker than Golden	more than 30 millimetres but not more than 50 millimetres
4. "Light Amber"	darker than Golden but not darker than Amber	more than 50 millimetres but not more than 85 millimetres
5. "Dark Amber"	darker than Amber but not darker than Dark	more than 85 millimetres but not more than 114 millimetres
6. "Dark"	darker than Dark	more than 114 millimetres

Table IV. Composition of Certain Kinds of Honey

Column I Composition of Honey	Column II Honeydew Honey	Column III Lavender, Ruginia, Alfalfa or Banksia Menziesii Honey	Column IV Blossom Honey other than the kinds named in Column III
1. Apparent reducing sugar calculated as invert sugar	not less than 60 per cent	not less than 65 per cent	not less than 65 per cent
2. Moisture	not more than 20 per cent	not more than 20 per cent	not more than 20 per cent
3. Apparent sucrose	not more than 10 per cent	not more than 10 per cent	not more than 5 per cent
4. Water-insoluble solids	(a) not more than 0.1 per cent, where not pressed (b) not more than 0.5 per cent, where pressed	(a) not more than 0.1 per cent, where not pressed (b) not more than 0.5 per cent, where pressed	(a) not more than 0.1 per cent, where not pressed (b) not more than 0.5 per cent, where pressed
5. Ash	not more than 1 per cent	not more than 0.6 per cent	not more than 0.6 per cent
6. Acid	not more than 40 milliequivalents per 1,000 grams	not more than 40 milliequivalents per 1,000 grams	not more than 40 milliequivalents per 1,000 grams

Sections 29 and 30

Container sizes for graded honey

a. any net weight up to and including 150 g	e. 750 g	i. 3 kg	m. 30 kg
b. 250 g	f. 1 kg	j. 5 kg	n. larger containers the net weight of which is measured in multiples of 1 kg
c. 375 g	g. 1.5 kg	k. 7 kg	
d. 500g	h. 2 kg	l. 15 kg	

Appendix E

Recommendations for Feeding Antibiotics

Handling and storage of antibiotics

Antibiotics are subject to degradation under heat and sunlight. Oxytetracycline and fumagillin must not be added to hot water or hot sugar syrup as the heat will destroy the antibiotics, and they will be rendered useless. Antibiotics should be added after the solution is cool or tepid.

Because sunlight degrades antibiotics, they should not be fed in exposed glass jars, as with boardman feeders, or jars above an inner cover unprotected from sunlight.

Oxytetracycline and fumagillin should not be used after the expiry date on the package. They should be stored in moisture-proof containers in a refrigerator or freezer and not be exposed to heat or sunlight.

Antibiotics should only be used at the recommended dosages for maximum effectiveness. Lower dosages will result in decreased protection while increased dosages may harm bees and brood.

Caution — *All feeding of antibiotics (oxytetracycline and fumagillin) must cease at least three weeks prior to the main honey flow to prevent honey contamination.*

Oxytetracycline

The bacteria causing both American and European foulbrood are susceptible to oxytetracycline. This drug does not kill the bacteria but acts to suppress germination and multiplication when ingested with the bacteria in the brood food.

Oxytetracycline is marketed by several companies under different trade names (the two most common are Terramycin by Pfizer and Oxytet-25 by Medivet).

Terramycin Animal Formula-25 and Oxytet-25 are both water soluble powders containing 25 g active ingredient per package. Other strengths and formulations can be used, but the dosage must be varied according to the activity of the formulation. Follow the directions for use on the package.

Oxytetracycline can be used as a preventive treatment against American foulbrood; however, it is not recommended as a cure. Before feeding oxytetracycline, hives must be examined for signs of AFB and all infested frames removed and destroyed.

Oxytetracycline may best be administered as a dry mixture of 5 parts icing sugar: 1 part Oxytetracycline 25 (by weight). The resulting mixture is applied at a rate of 30 mL (2 tablespoons) per colony across the ends of the top bars so as to avoid direct contact with open brood, as this can cause brood mortality. Only mix enough to use immediately because the mixture will lose potency with storage. Colonies exhibiting foulbrood symptoms should be treated with the mixture every 7 to 10 days until 3 weeks prior to the honey flow.

Oxytetracycline may also be administered in sugar syrup at a rate of 5 mL (1 teaspoon) oxytetracycline-25 per 4.5 L (1 gallon) for overwintered and package colonies. One package (400 g) of Terramycin is sufficient for 450 L (100 gallons) sugar syrup.

It has been shown that oxytetracycline breaks down in solution and loses its effectiveness with time. Therefore, medicated syrup should be used immediately and should be consumed within one week. Otherwise, the dusting method should be used for spring medication.

Conversions

$$1 \text{ mm} = 0.039 \text{ in.}$$

$$1 \text{ kg} = 2.12 \text{ lb}$$

$$1 \text{ L/s} = 2.12 \text{ cfm}$$

$$1 \text{ Pa} = 0.004 \text{ in. water}$$

$$1 \text{ m}^2 = 10.75 \text{ ft}^2$$

$$1 \text{ cm}^2 = 0.155 \text{ in.}^2$$

$$1 \text{ W} = 3.414 \text{ BTU/hr}$$

$$1 \text{ RSI} = 5.68 \text{ "R"}$$

$$1 \text{ in.} = 25.4 \text{ mm}$$

$$1 \text{ lb} = 0.454 \text{ kg}$$

$$1 \text{ cfm} = 0.472 \text{ L/s}$$

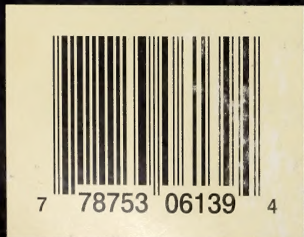
$$1 \text{ in. water} = 250 \text{ Pa}$$

$$1 \text{ ft}^2 = 0.093 \text{ m}^2$$

$$1 \text{ in.}^2 = 6.45 \text{ cm}^2$$

$$1 \text{ BTU/hr} = 0.293 \text{ W}$$

$$1 \text{ "R"} = 0.176 \text{ RSI}$$



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